Disordered Speech in Dementia

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Declaration

I declare that this dissertation is the result of my own work and is not the outcome of work done in collaboration. A paper containing Experiment 2 appears in the Proceedings of the Fifteenth Annual Conference of the Cognitive Science Society (1993). Experiment 2 also appears in Astell, A. J. & Harley, T. A. Tip-of-the-tongue states and lexical access in dementia. Brain and Language (in press).

I have not submitted this dissertation or any part of it for any other degree or diploma or other qualification at any other university.

Summary

What is the effect on language of the progressive degenerative disorder, Alzheimer's disease (AD)? What are the functional consequences of this illness, particularly for speech? The majority of accounts interpret speech disorder in AD as reflecting underlying semantic disruption. In contrast I apply current theories of lexicalization in speech production to the speech disorder. Four competing hypotheses are derived from a two-stage model of lexicalization in speech production. This model contains separate semantic, lexical and phonological representations. Data are collected from patients with probable AD and age-matched controls using standard psycholinguistic techniques. The data support an explanation of progressively impaired higher level cognitive processing which interacts with impaired semantic to lexical processing in speech production.

Chapter 1

Introduction

How is language affected by dementia? In particular, what is the effect on speech? In this thesis I explore speech disturbance in dementia in the context of current approaches to speech production. My main concern is with the progressive degenerative illness, Alzheimer's disease (AD), which disrupts normal functioning in all cognitive domains. I focus on speech production but in the wider context of global language deterioration.

In 1907 Alzheimer described a case of the illness to which his name became attached. His 51 year old patient exhibited global cognitive deterioration with some functions, such as speech, more impaired than others. He was the first to identify neurofibrillary tangles, which were present in this patient alongside the neuritic plaques described by Redlich (1898). These plaques and tangles came to be seen as characteristic of AD, their presence at post-mortem confirming the diagnosis. Recognised as probably the biggest single cause of dementia, AD has come to be the diagnosis of default or exclusion (McGlone & Gupta, 1986; Neary et al., 1986) when other causes of dementia, such as multiple infarctions, are screened out. Thus AD is assumed purely as a consequence of other causes having been ruled out, rather than it having been positively diagnosed. One consequence of this is that AD is often erroneously diagnosed (Geschwind, 1980). Another outcome is that the label AD has been applied to such a huge range of signs and symptoms that obtaining a clear picture of the disorder is at best complex, at worst impossible.

One contributory reason is that the impairments associated with AD were mainly attributed to general cortical deterioration (Grünthal, 1926; Kahn, 1925; Stertz, 1921). In particular, a global impairment in memory was cited as the underlying cause of most symptoms (Rothschild, 1934). Previous attempts to characterise the language disorder of AD have been influenced by this view of dementia as one disorder of global impairment. As a result cases were researched, interpreted and reported without regard to differences in aetiology (e.g. Barker & Lawson, 1968; Critchley, 1964; Lawson & Barker, 1968; Pichot, 1955; Stengel, 1964). In addition, where aetiologically distinct subjects were used, findings were often reported for all subjects together (Allison, 1962; Irigaray, 1967). A further complication has been the practice of some commentators either to adopt the labels of the aphasias, or at least draw parallels with them (e.g. Albert, 1980; Appell, Kertesz & Fisman, 1982; Cummings, Benson, Hill & Read, 1985; Hier, Hagenlocker & Shindler, 1985; Obler & Albert, 1981; Powell, Cummings, Hill, & Benson, 1988; Schwartz, Marin & Saffran, 1979). For instance Hier et al. (1985) liken the speech disturbance of mild Alzheimer-type patients to anomic aphasia and of more severely impaired patients to Wernicke's or transcortical sensory aphasia. They contrast this with speech disorders associated with dementia following a stroke, which they compare to Broca's aphasia. Whilst such comparisons may provide a general picture of speech disorders associated with dementia, they fail to portray the degenerative nature of the conditions. In addition, a comparison of the spontaneous speech of AD patients and Wernicke's aphasics suggests that the two display clearly dissociable disorders (Blanken, Dittman, Haas & Wallesch, 1987). The importance of distinguishing the dementias and the language disorders associated with them, however, has been stressed only relatively recently (Appell et al., 1982; Geschwind, 1980; Obler & Albert, 1981).

In the past 15 years, aetiological distinction of the patterns of deficit has progressed. At the same time, the co-occurrence of different patterns within individual disorders has been recognised. This is particularly so in AD. One reason for this may be the recognition that different studies have sampled different stages of the disease process. As AD is a degenerative disorder, the features of the disturbance change as the disease progresses. A second reason for distinguishing patterns of deficit in AD is the increasing recognition that there are different presentation patterns of the disorder (Bandera, Della Sala, Laiacona, Luzzatti & Spinnler, 1991; Becker, Huff, Nebes, Holland & Boller, 1988; Goldstein, Green, Presley & Green, 1992; Martin, 1990; Martin et al., 1984; Martin, Brouwers, Cox & Fedio, 1987; Neary et al, 1986). In other words, not all patients present with the same patterns of impaired and preserved functions. Martin, Cox, Brouwers and Fedio (1985) identified three different presentation profiles among their PRAD patients. These are semantic/lexical impairment, visuospatial impairment and global impairment (Martin et al., 1985). Martin (1990) refers to these as subgroups. That these different patterns of impairment can be attributed to a single underlying memory disorder is no longer accepted (Marshall, 1990; Schwartz, 1990; Spinnler & Della Sala, 1988). This is supported by neuropathological evidence which indicates that degeneration is selective rather than diffuse (Chawluk et al., 1990; Damasio, Van Hoesen & Hyman, 1990; Schwartz, 1990). A third reason for recognising different patterns of deficit and preservation is the delineation of disorders claimed to be distinct from AD. It is likely that these have previously been included in its clinical picture. Most notable are primary progressive aphasia (PPA; Mesulam, 1982; Weintraub, Rubin & Mesulam, 1990), semantic dementia (SD; Hodges, Patterson, Oxbury & Funnell, 1992; Snowden, Goulding, & Neary, 1989) and dementia of the frontal type (DFT: Gregory & Hodges, 1993; Gustafson, 1987; Hodges, 1993; Neary, Snowden, Northen & Goulding, 1988; Orrell & Sahakian, 1991). The contribution of subgroups and separable disorders to our understanding of the language disorder of AD is examined in Chapter 2.

1.1 Outline of the language disorder of AD

Language disturbance has been consistently reported as a feature of AD. In particular, naming problems are considered to be a prominent early feature (Barker & Lawson, 1968; Bayles, 1982; Bayles & Tomoeda, 1983; Bayles, Tomoeda & Trosset, 1990; Cummings et al., 1985; Kirshner, Webb & Kelly, 1984; Martin & Fedio, 1983;

Shuttleworth & Huber, 1988). Other consistently reported features are impaired performance on verbal fluency tasks (Bayles, Salmon, Tomoeda, Jacobs, Caffrey, Kaszniak, & Tröster, 1989; Bandera et al., 1991; Benson, 1979; Becker et al., 1988; Chertkow & Bub, 1990; Goldstein, et al., 1992; Hart, Smith & Swash, 1988; Huff, Corkin & Growdon, 1986; Martin et al., 1986; Stuss & Benson, 1986); circumlocutory responses (Appell et al., 1982; Hodges, Salmon & Butters, 1991; Kertesz, Appell & Fisman, 1986; Stengel, 1964); preservation of phonemic processes (Appell et al., 1982; Hodges et al., 1991; Kertesz et al., 1986) and the relative preservation of syntactic processes (Appell et al., 1982; Bayles, 1982; Hier et al., 1985). As indicated above, different authors have reported different patterns of features, some of which appear contradictory. For instance Ober, Dronkers, Koss, Delis and Friedland (1986) found patients with probable AD were equally impaired on verbal fluency with semantic categories and letters. Butters, Granholme, Salmon, Grant and Wolfe (1987) found that patients with probable AD performed as well as controls with letters but were significantly impaired with semantic categories. Hart et al. (1988) reported that whilst performing worse than controls with both letters and categories, generation from categories was significantly better than for letters.

1.1.1 The semantic account

The most common interpretation of the language disorder in AD is as the manifestation of an underlying semantic disorder. One reason for this is that analysis of error responses, particularly on naming tasks, consistently reveals that the majority are semantically related to the target with no tendency to make phonological errors (Appell, et al, 1982; Bayles, 1982; Bayles & Tomoeda, 1983; Hodges, Salmon & Butters, 1991; Hodges et al., 1991). Tippett and Farah (1994) identified semantic, visual and lexical accounts in their review of the literature on the naming disorder in AD. They simulated patterns of responding in naming tasks in AD by lesioning a connectionist model and concluded that a semantic impairment could account for all of the findings. Nebes (1989) comprehensively reviewed the findings from many language tasks and reached a similar conclusion. Explanations of the semantic disorder, following Warrington and Shallice (1979), focus on whether it reflects an impairment of *access to semantic representations* (Nebes, Martin & Horn, 1984; Diesfeldt, 1985) or an impairment of the actual *stored representations* (Chertkow & Bub, 1990a, b; Hodges et al., 1991, Hodges, Salmon & Butters, 1992, 1993; Huff et al., 1986; Martin & Fedio, 1983; Salmon, Shimamura, Butters & Smith, 1987). The evidence offered in support of both the access and storage accounts is examined in Chapter 2.

Distinguishing between the access and storage accounts in AD has attracted much research, and particularly notable is the work of Chertkow and Bub (1990a,b; Chertkow, Bub & Caplan, 1992; Chertkow, Bub & Seidenberg, 1989) and Hodges, et al. (1991, 1992, 1993). Both of these groups favour the disrupted storage account based on Tulving's (1972) description of semantic memory (Chertkow & Bub, 1990a, b; Hodges et al., 1992). Tulving considered semantic memory to contain the lexicon, grammatical rules and the knowledge required to manipulate incoming stimuli. With words and their referents part of the same store, it is difficult to distinguish if problems lie with concepts (semantic information) or labels for concepts (lexical items) or with both. Among the noted difficulties in AD are semantic substitutions, word-finding problems and circumlocutory responses, where participants explain the function of a to-be-named item, rather than actually naming it. Responses such as these suggest that at least part of the problem lies with retrieval of lexical representations. In a model where semantic and lexical items are considered to be linked but stored separately, further investigation of the locus of breakdown is possible.

1.1.2 Speech production framework

In order to produce a clear picture of the language disorder of AD, it is necessary to distinguish between semantic and lexical representations. It is therefore appropriate to apply current knowledge about speech production to the language disorder of AD. This, with the notable exception of the work by Blanken et al. (1987), has not been done in any systematic way.

In this thesis I use a two-stage model of lexicalization in speech production. Lexicalization is the process of moving from a semantic specification of what is to be said to the phonological form of the words retrieved. Both the emergence of two-stage models and the debate over whether processing are serial or overlapping is considered in Chapter 3. Two-stage models contain separate semantic, lexical and phonological representations. The first stage of lexical retrieval involves the selection of an abstract lexical item (*lemma*) from the semantic specification. The second stage is the retrieval of the detailed phonological form of the word (sometimes called the *lexeme*.) On the basis of the evidence reviewed above, I will be concentrating on the semantic-to-lexical, lemma stage of lexicalization. Separate storage of knowledge about concepts and of the labels for the concepts permits investigation to distinguish between problems accessing or storing semantic information or similar problems with lexical information.

In this investigation I will draw most strongly on the interactive activation model of Harley (1990, 1993; Harley & MacAndrew, 1992). This is a connectionist model in which semantic, lexical and phonological levels are connected (See Figure 1). Each unit is connected to every unit in the following layer with appropriate between-level connections facilitatory, and inappropriate connections inhibitory. There is within-level lexical and phonological level inhibition, and feedback connections between phonological and lexical levels. This model acknowledges previous work and ideas from Dell (1986) and Stemberger (1985). Appell et al. (1982) suggested that in AD there may be "...a loosening of ... links between words and between words and the things that they represent" (page 75). This fits well into the above account either as a problem at the lexical level or with the connections between the semantic and lexical levels. In addition, Miller (1979) suggested that increased retrieval failure in dementia could result from disinhibition of plausible alternatives. This disinhibition explanation also fits well into the connectionist two-stage account of lexicalization outlined above, where within-level inhibition is an important processing mechanism.

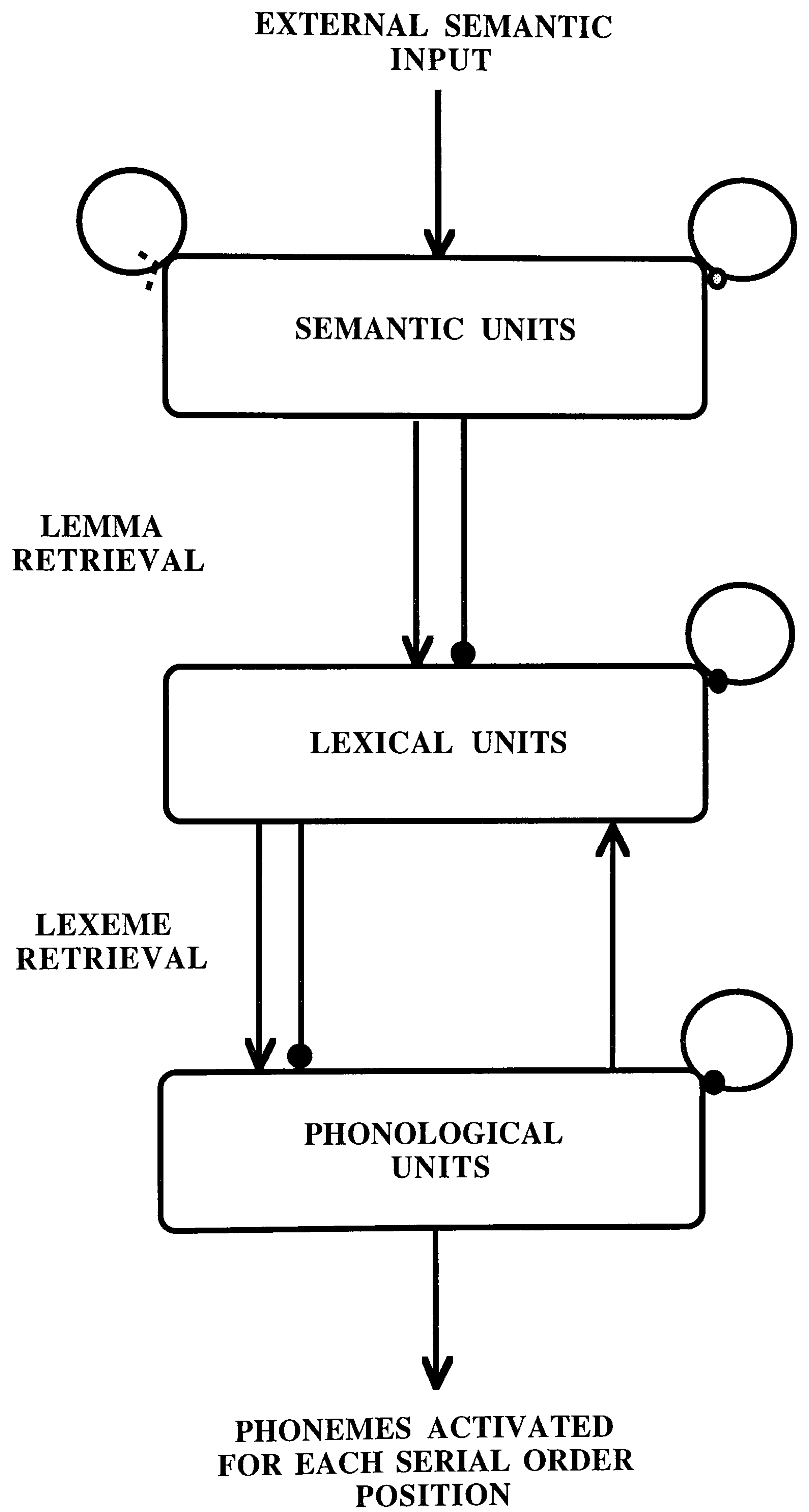


Figure 1. The detailed architecture of Harley 's IAA model of lexicalization. (Harley & MacAndrew, in press)

Problems at the lemma stage of lexicalization may arise through disruption at the semantic level, the lexical level, or in the links between the two levels. At the semantic level the semantic specification itself may be impaired. In Harley's (1993) model concepts are represented as a set of defining attributes. Should one or more distinguishing features be lost, then semantically related items that share the remaining features, could be output. Over time, increasing amounts of semantic information may be lost, resulting in random output. At the lexical level the representations of lexical items could be weakened or lost. There could also be a problem with the within-level inhibitory links between competing items which may become weakened. The links between the semantic and lexical levels are also vulnerable and may weaken and eventually become lost. In a degenerative disorder it is possible that several, if not all, of these types of disruption may occur over time.

1.1.3 Alternative explanations

An underlying semantic impairment is undoubtedly the most frequently given explanation of speech disorder in AD. Among the alternative accounts are two others that I wish to introduce. First is the conclusion of Bayles, Tomoeda, Kaszniak & Trosset, (1991) that AD causes task-specific impairments rather than item-specific, semantic impairment. They interpret poor performance in their probable AD patients as reflecting differences in task difficulty rather than an underlying semantic impairment. They urge caution in the interpretation of tasks designed to explore semantic processing without regard to relative task difficulty. This study is further discussed in Chapter 8.

The second alternative to the semantic impairment account is that given by Blanken et al. (1987) of spontaneous speech production in patients with AD. They present a neurolinguistic model of speech production that includes a pre-linguistic planning stage, a formulation stage and an articulatory stage. In their model, lexicalization is a two stage process at the formulation stage. From a comparison of the spontaneous speech of AD patients and Wernicke's aphasics they conclude that in AD there is a problem at the pre-linguistic, planning stage. They reported no apparent word finding difficulty in the AD group, although they noted a decrease in noun production relative to age-matched controls. This account applies particularly to spontaneous speech and Blanken et al. (1987) agree with Stengel (1964) that word finding difficulties in AD are more apparent in test situations than in spontaneous speech. Further consideration of their model is made in Chapter 3 (section 3.3).

These two accounts of speech disorder in AD offer important additional considerations. It is noted above that there are ambiguous and contradictory findings in the AD literature. In addition to the explanation given above relating to sample severity, the differing requirements and demands of tasks being compared could account for some of the discrepancies. Task demands also interact with the finding that AD patients have a problem with the content-planning stage of speech production. Thus tasks relying on spoken responding must be interpreted within this constraint.

1.2 Outline

The main hypothesis of this thesis is whether or not the language impairment in Alzheimer's disease arises from a semantic impairment? This is investigated through a variety of standard psycholinguistic techniques, such as picture naming, the tip-of-the-tongue (TOT) phenomenon, picture-word matching and verbal fluency. The aim of the tasks is to identify whether semantic representations are impaired. If they appear not to be, then where in the lexicalization system are errors arising? Error analysis suggests that phonological representations remain intact in AD well into the deterioration process. Thus the locus of errors, if it is not in the semantic representations, must be post-semantic but pre-phonological.

In Chapter 2 I review the evidence for explaining the language disorder of AD in the context of a model of semantic retrieval and lexical access that has separate semantic and lexical representations. In Chapter 3 I examine the evidence for two-stage models of speech production that include separate semantic, lexical and phonological representations. Chapter 4 contains a description of the participants and background data collected. Chapter 5 describes two experiments. Experiment 1 is a naming and word-picture matching task and Experiment 2 is a study of the TOT phenomenon. The results of these indicate that the spoken language disorder in PRAD arises at the semantic-to-lemma stage. The competing explanations for this lemma problem are investigated in Experiments 3, 4, 5, and 7, contained in Chapters 6 and 7. Twenty-four target items were selected from four categories (six from each) within the constraints of word frequency and typicality. Experiment 3 is a verbal fluency task using the four categories. Experiment 4 is a second naming and matching task and Experiment 5 is a second study of TOTs. Experiments 6 and 7 examine verbal definitions of the 24 words. In Experiment 6 the definitions are provided by a group of healthy adults which are analysed for the components that comprise a satisfactory definition. Experiment 7 is an analysis of definitions of the same targets made by PRAD participants. In Chapter 8 performance of six PRAD participants who carried out each of Experiments 3, 4, 5 and 7 is examined. Chapter 9 contains Experiments 8 and 9 which are follow-up studies. Experiment 8 is a third TOT study comparing written and spoken responding and Experiment 9 is a semantic rating task. Chapter 10 contains the conclusions.

Chapter 2

Speech disorder and semantic memory

In this chapter, I review the speech characteristics commonly reported in PRAD. These include reduced information content in speech, problems with naming objects and pictures and reduced ability to generate items from given semantic categories. The most commonly appealed to interpretation of these findings is that PRAD patients suffer from an impairment of semantic memory. Thus naming problems reflect impaired item-knowledge while reduced category generation reflects impaired category-knowledge. Such interpretations reflect certain assumptions about semantic memory, in particular about the relationship between concepts and labels. These assumptions require explanation to understand the interpretations of disordered speech in PRAD. Thus, I first consider the elements of semantic memory theory that have influenced understanding of the speech disturbance.

The main experimental findings follow this. Some researchers have focused on specific tasks in isolation, whilst others have combined series of measures to probe the relationships between them. For convenience, I group the findings under headings related to the speech production measures used. Tasks designed to investigate the proposed underlying semantic disorder in PRAD, but not directly assessing speech functioning, are considered separately. In this chapter I also consider the evidence for distinguishing different patterns of deterioration within PRAD and identifying as separate disorders, patterns of impairment previously labelled as AD. I examine the implications of these moves for speech dysfunction in PRAD.

2.1 Semantic memory

Many commentators attribute speech disorder in PRAD to an underlying semantic disorder (e.g. Bayles & Tomoeda, 1983; Chertkow & Bub, 1990a,b; Hodges et al., 1991). To examine this approach requires an understanding of certain key elements of the theory of semantic memory. The first element is the distinction drawn between semantic and episodic memory by Tulving (1972). Although Tulving has subsequently revised his approach (1985, 1987) and non-supportive experimental data (Parkin, 1993) make the distinction dubious, his original formulation of semantic memory remains very popular. Second is the structure of semantic memory. In particular the representation and organisation of information and their retrieval implications. Third are the popular criteria for distinguishing semantic storage from semantic access disorders (Warrington & Shallice, 1979). Fourth is the debate over whether semantic memory comprises a unitary, amodal store or separate, modality-specific stores. This is important for applying the criteria to distinguish between access and storage disorders. Fifth is the notion of automatic and effortful processing. Whilst this does not just apply to semantic processing, tasks that tap implicit semantic knowledge are useful, especially when explicit, effortful tasks, are difficult to carry out.

2.1.1 The episodic/semantic distinction

Tulving's (1972) distinction between episodic and semantic memory has had a great influence on research over the last twenty years. In the early formulation both contained propositional information but differed qualitatively from each other. Episodic memory consisting of autobiographical memories, such as the sights, sounds, tastes and smells of your last holiday and semantic memory of knowledge about things, such as the names of capital cities and what an apple is. Tulving defined semantic memory as stored knowledge about words, their referents, their meanings and the relationships between them. The rules for manipulating this stored knowledge are also in semantic memory. Tulving (1972: 386) emphasised the status of words, calling semantic memory "a mental thesaurus" and stating that it contained the lexicon. Despite alternative descriptions of semantic memory that remove the emphasis from stored word meanings (e.g. Cohen, 1983) it is this aspect that has been most influential, particularly in neuropsychology.

2.1.2 The structure of semantic memory

There are two inter-related issues in considering the structure of semantic memory. These are organization and the nature of representations. Evidence from a variety of experimental techniques suggests that humans organise information categorically (Cohen, 1983; Miller, 1971). Attempts to capture the relationships within and between categories are either network-based or feature-based. Network models contain nodes, which represent concepts, connected by links, which represent the relationships between them. Among these are the hierarchical network model (Collins and Quillian, 1969), the spreading activation network (Collins & Loftus, 1975) and the marker-search model (Glass & Holyoak, 1975). In feature-based models concepts are represented by defining features or attributes, with similarity represented by the number of shared features. Examples are the predicate-intersection model (Meyer, 1970), the feature-comparison model (Smith, Shoben & Rips, 1974), the property-comparison model (McCloskey & Glucksberg, 1979) and prototype theory (Rosch, 1973).

There are many similarities between network and feature models. Drawing a distinction between them has been described as both "vacuous" (Hollan, 1975) and irrelevant to our understanding of semantic memory (Chang, 1986: Johnson-Laird, Herrmann & Chaffin, 1984; Kintsch, 1980). There also exist models that combine elements of both networks and features (e.g. Katz & Fodor, 1963). In particular distributed models of memory (e.g. McClelland & Rumelhart, 1985) offer a synthesis of the main elements of the two types of model. In these, concepts are represented by patterns of activation across a combination of nodes, each signifying an attribute. These models perhaps best illustrate neuropsychological assumptions about information in semantic memory. To summarise, semantic memory is popularly represented as containing concepts, defined by features, connected to related concepts.

In addition to these features, it is also widely held that there are different levels of representation in semantic memory. Rosch, Mervis, Gray, Johnson and Boyes-Braem (1976) proposed that naturally occurring categories are arranged in three tiers. These are a *superordinate* level (e.g. clothing, vegetables), a *basic* level (coats, potatoes) and a *subordinate* level (e.g. overcoat, King Edward's). Attributes represent concepts and are grouped together in defining sets. The basic level contains the most distinctive attributes of the category and is the commonly used level of representation. Rosch et al. (1976) based these proposals on experimental findings and the tasks used, such as category fluency, categorisation and semantic rating, are commonly employed in neuropsychological investigations to probe the integrity of semantic storage. This terminology and organization have been regularly adopted and adapted for investigations into semantic memory in PRAD (e.g. Bayles et al., 1990; Chertkow & Bub, 1990a,b; Hodges, Salmon & Butters, 1992).

An example of the bringing together of Rosch's levels of categorisation and Tulving's lexicon in neuropsychology is the literature on access to word meanings (Warrington, 1975; Warrington & McCarthy, 1983; Warrington & Shallice, 1979). The main claim is that access to word meanings is via the superordinate level, that is going from the general level to the specific item. This idea was developed to account for patients whose specific item knowledge is apparently impaired in the face of retained category knowledge. However, Rapp and Caramazza (1989) found no support for various hypotheses derived from this theory in a patient with such a profile. Thus debate continues on the issue of hierarchical organization of semantic information, or at least that lower levels are lost before higher levels (see also 2.1.3 below).

2.1.3 Access versus storage disorders

Impaired access to an intact semantic store or degradation of the actual store itself, starting with low level specific items, leaving broader, general categories spared, are the most common explanations of semantic impairment (Warrington & Shallice, 1979). Warrington and Shallice (1979) proposed four characteristics to enable distinction between these two causes. First is *consistency*. If storage is impaired, then an individual's responses should show a consistent pattern over different test sessions. Inconsistent responses result from a problem accessing an intact store. A second criterion is *priming*. If the store is degraded then it should not be possible to prime an item. If, however, the item is inaccessible then priming should facilitate its production. Third is *frequency*. This suggests that less frequent items have smaller representations and thus are more susceptible to being lost in a storage disorder. In an access disorder, the relationship between frequency and failure should be considerably reduced. The fourth characteristic is *depth of processing*. With both types of impairment, the superordinate category should be easier to obtain than the item, as the former is larger and more strongly represented (but see Rapp & Caramazza, 1989). In a storage disorder, providing attribute knowledge should be very difficult. In an access disorder, the presence of the superordinate should facilitate retrieval of attribute knowledge. Warrington and McCarthy (1983) suggested a fifth feature, that of sensitivity to the *rate of presentation*. They found that a patient with an inconsistent pattern of responding improved if there was an interval between responding to one item and presentation of the next. Shallice (1988) considers that consistency and priming are the two distinguishing features with most face validity. However, the validity of consistency, in particular the statistical measures used to assess it, has recently been questioned (Faglioni & Botti, 1993). In addition the underlying assumptions of all these criteria have been examined and found wanting (Caplan, 1992; Rapp & Caramazza, 1993). This said, exploration of the semantic disorder in PRAD has made much use of these criteria and they are widely referred to in the data presented below.

2.1.4 Unitary versus separate storage

Consistency in responding implies a single store of semantic information as it suggests a single representation has been lost. This is a common underlying assumption in many explanations of cognitive neuropsychological findings (Caramazza & Hillis, 1990; Caramazza, Hillis, Rapp & Romani, 1991; Hillis & Caramazza, 1991; Hillis, Rapp, Romani & Caramazza, 1990; Humphreys & Riddoch, 1988; Riddoch, Humphreys, Coltheart & Funnell, 1988). However, certain neuropsychological cases have raised the possibility of separate, modality-specific semantic stores (Shallice, 1988, 1993; Warrington & Shallice, 1979). Three types of evidence are interpreted as support for this position (Caplan, 1992; Shallice, 1988). First, patients with specific, modality-related naming impairments, such as optic aphasia (Freund, 1889) are offered as support for this approach (Shallice, 1988). Such disorders are seen as resulting from loss of a modality specific semantic store. Second, reports of patients with category-specific impairments, that is sparing of one class of items (e.g. living things) relative to impairment of another class (e.g. non living), are interpreted as offering further support (Hart, Berndt & Caramazza, 1985; Shallice 1988; Warrington, 1975). These impairments suggest the existence of different semantic stores containing information about living and non living items. A third class of findings offered in support of separable semantic subsystems is the modality-specific effects of priming (Shallice, 1988). Studies showing a lack of cross-modal transfer (e.g. Warren & Morton, 1984) can be interpreted as indicating separate modality-specific stores. The modality distinction is usually between storage of visual and verbal information (Shallice, 1988; Warrington & McCarthy, 1983, 1987; Warrington & Shallice, 1984). Consistency in responding is explained as degradation of the separate modality-specific stores (Shallice, 1988). Patients with greater impairment in one domain than the other, suggest that this degradation can be differential (Shallice, 1988; Warrington, 1975).

Evidence linking two of the above comes from the emergence of category-specific impairments following lesioning of a modality-specific model (Farah & McClelland, 1991). However, the modalities used were visual and functional rather than visual and verbal. Visual information was important for distinguishing living things and functional for non living. In this distributed model concepts are represented as a pattern of activation across interconnected nodes, with individual units representing different elements of the whole. Some of the units signify visual information and some functional. Each living and non living item is represented by a distinct pattern of these units. So although visual and functional information is coded separately, the overall representation arises from a combination of both. Thus the extent to which the two domains are independent is debatable. Challenges to the other supporting evidence come from alternative accounts of optic aphasia, both from a different, hemispheric, multiple store account (Coslett & Saffran, 1991), from a unitary store one (Riddoch & Humphreys, 1987; Riddoch et al, 1988) and from a simulation with a distributed representation (Plaut, 1991). In addition, the evidence for a living/non living distinction in semantic memory has been challenged (Caplan, 1992; Funnell & Sheridan, 1992; Gaffan & Heywood, 1993). Similarly, the interpretation of prompting or cueing supporting independent visual and verbal semantic systems has been questioned (Caplan, 1992). Indeed, Caplan (1992), offered an alternative account to the multiple store for all three types of evidence, based on the assumption that accessing concepts via objects and via words uses different processes (Caplan, 1992).

2.1.5 Automatic and effortful processing

Semantic priming is commonly used to investigate semantic memory in healthy subjects (Bowles & Poon, 1985; Irwin & Lupker, 1983; see Neely, 1991 for a review of the semantic priming paradigm). Semantic priming is also a popular tool for use with neuropsychological patients, not least because it is a relatively automatic process (Besson, Fischler, Boaz & Raney, 1992; Bub, Black, Hampson & Kertesz, 1988; Nebes et al., 1984), requiring small amounts of limited attentional capacity. An oft-cited example of the subtle power of priming is the finding of Milberg and Blumstein (1981) that a group of aphasics who showed no awareness of the semantic relationships among a set of items could be semantically primed by them. By contrast tasks such as delayed and free recall are effortful processes (Grafman et al., 1990; Morris, 1986; Weingartner, Grafman, Boutelle, Kaye & Martin, 1983) and require large amounts of attention (Hasher & Zacks, 1979). Such tasks show greater impairment in both healthy elderly (Hasher & Zacks, 1979) and brain-injured populations (Nebes et al, 1984; Rissenberg & Glanzer, 1987).

Semantic information has been shown to influence item recall in healthy subjects (McKoon, Ratcliff & Dell, 1985), so a problem with semantic processing in PRAD should affect episodic tasks. PRAD performance is significantly worse than controls on a variety of effortful recall measures such as delayed matching to sample (Money, Kirk & McNaughton, 1992) and spatial order memory (Adelstein, Kesner & Strassberg, 1992). In addition, digit span scores (WAIS-R) and other measures indicate reduced short term memory capacity in PRAD (Funnell & Hodges, 1991; Hart, Smith & Swash, 1986; Moscovitch & Umilta, 1990). This may be due to a reduction in available central processing resources (Morris, 1986). Further evidence for this reduction is the finding of severely impaired dual task performance in PRAD relative to controls (Baddeley, Bressi, Della Salla, Logie & Spinnler, 1991; Morris, 1986, 1987), even when individual task performance is at the same level. Thus, automatic tasks, requiring little attentional capacity have an obvious appeal for use with PRAD patients.

2.2 Speech production measures

Alteration in language function is one of the most noticeable features in PRAD. Language assessment may be useful diagnostically (Bayles, 1982; Bayles & Boone, 1982) at least for separating dementing from healthy elderly (Cummings et al., 1985; Kontiola, Laaksonen, Sulkava & Erkinjuntti, 1990) and perhaps for distinguishing PRAD from other causes of dementia (Appell et al., 1982). Assessment of language may be useful for illuminating the stages of deterioration that characterise PRAD (Kertesz et al., 1986). It may also serve a prognostic function (Boller et al., 1991; Kaszniak et al, 1978), although not all investigators have found this relationship (Burns, Lewis, Jacoby & Levy, 1991).

A problem with word finding is one of the earliest noted characteristics of speech in PRAD (Diesfeldt, 1985; Nebes, 1989; Rissenberg & Glanzer, 1987; Skelton-Robinson & Jones, 1984). This is particularly noticeable for nouns, but is also apparent with verbs (Bowles, Obler & Albert, 1987). Analysis of spontaneous speech samples is one way to explore word-finding difficulty. Samples are usually conversations or descriptions of pictures and objects. In an attempt to chart the patterns of impaired and preserved functions, analysis is made of syntactic, semantic and pragmatic aspects of speech. Other measures commonly used to investigate word-finding problems are confrontation naming of objects and pictures, naming to definitions and verbal generation tasks.

2.2.1 Spontaneous speech

Spontaneous speech in PRAD remains fluent with appropriate syntactic structure (Appell, et al., 1982; Blanken et al., 1987; Kirshner et al., 1984; Neary et al., 1986). The motor functions of speech are relatively unimpaired until the disease process is very advanced (Appell et al., 1982; Herlitz, Adolfsson, Bäckman & Nilsson, 1991; Constantinidis, Richard & de Arjuriaguerra, 1978; Hier et al., 1985; Powell et al., 1988). Whilst utterances are shorter than those of age-matched controls (Blanken et al., 1987; Ripich, Vertes, Whitehouse, Fulton, & Ekelman, 1991) PRAD patients retain the structure of turn-taking and other features of orderly conversation (Ripich et al., 1991). PRAD subjects make more unintelligible responses in conversation than age-matched controls (Ripich et al., 1991). In addition, more non-verbal responses are made by PRAD subjects, which Ripich et al. (1991) interpret as compensatory strategies.

The content of PRAD speech is often irrelevant to the current conversation (Appell et al., 1982). In addition, the amount of information in PRAD speech differs significantly from age-matched controls (Cummings et al., 1985) and patients with multi-infarct dementia (MID: Powell et al., 1988). It contains fewer nouns and more verbs and adverbs than that of controls (Blanken et al., 1987). Whilst retaining lower frequency items (Miller & Hague, 1975) PRAD speech contains a large amount of semantic substitutions (Appell et al., 1982). There is an increased, and often inappropriate, use of conjunctions and decreased awareness of the pragmatic aspects of communication (Obler & Albert, 1981). Overall communicative function is low due to the reduced information content (Constantinidis et al., 1978). The conversation of PRAD patients contains more requestive speech acts, seeking information, and less assertive ones, giving information, than controls' (Ripich et al., 1991). The maintenance of conversational ability through the development of compensatory strategies, suggests that in PRAD the communication system remains flexible, even after the content has started to disintegrate (Ripich et al., 1991).

2.2.2 Verbal descriptions

Reduced information and compensatory strategies are also a feature of descriptions made by PRAD patients (Bayles, 1982). Even descriptions by mild PRAD patients of a painting (Bayles, Boone, Tomoeda, Slauson & Kaszniak, 1989) and simple, common objects (Bayles, 1982; Bayles, Boone et al., 1989) contained significantly less information than age-matched controls'. Changing the subject or repeating information may mark attempts to conceal or compensate for the shortfall in information (Bayles, 1982). This strategy suggests retained speech monitoring ability in the early stages of PRAD (Bayles, 1982). Moderately impaired patients show less awareness of the appropriateness of utterances and decreased meaningfulness of the content (Bayles, 1982; Bayles, Boone et al., 1989). In severely impaired patients, whilst speech remains fluent and phonology largely intact, the content is virtually meaningless (Bayles, 1982). As information decreases with severity so the number of perseverations in PRAD descriptive speech increases (Bayles, Tomoeda, Kaszniak, Stern & Eagens, 1985).

PRAD descriptions of the Cookie Theft picture from the Boston Diagnostic Aphasia Examination (B.D.A.E; Goodglass & Kaplan, 1976) also contain reduced information

(Hier et al., 1985). As severity increases so does the use of pronouns and errors in selecting prepositions, whilst the number of relevant observations made decreases. There is no decrease in the overall number of words used and preserved syntactic complexity. Also using the Cookie Theft, McNamara, Obler, Au, Durso and Albert (1992) examined the ability of mild-moderate PRAD patients to detect and repair speech errors. Monitoring of output errors consists of either *lemma repairs*, which comprise word substitutions, or *reformulation repairs*, which involve syntactic changes. PRAD patients corrected only 24% of their errors, mainly reformulations, compared with 92% for a control group, mainly lemma repairs. There was a negative correlation between ability to detect errors and performance on the Boston Naming Test (McNamara et al., 1992).

2.2.3 Naming

Naming problems are widely considered an early and characteristic sign of PRAD (Bayles & Tomoeda, 1983; Bowles et al., 1987; Goldstein et al., 1992; Hart, 1988; Hodges et al., 1991, Martin & Fedio, 1983, Tippett & Farah, 1994). Naming performance is a particularly good predictor of rate of decline in PRAD (Boller, et al. 1991) and correlates with severity (Hodges et al., 1991; Kirshner et al., 1984; Neils, Brennan, Cole, Boller & Gerdeman, 1988; Skelton-Robinson & Jones, 1984).

The majority of erroneous naming attempts are semantically (Bayles & Tomoeda, 1983; Blanken, et al., 1987; Hodges et al., 1991) or visually (Bayles & Tomoeda, 1983; Blanken, et al., 1987; Hodges et al, 1991; Rochford, 1971) related to the target. In the early stages problems with semantic processing underlie the majority of errors. As the illness progresses, responses become less and less semantically related (Bayles & Tomoeda, 1983; Bayles et al., 1990; Constantinidis et al., 1978). Early investigators interpreted their findings in relation to the two-stage model of naming proposed by Oldfield and Wingfield (1965, 1966). The first stage is recognition of the item. The second stage is a search through the word store for the name of the recognised item. Visual errors are explained by a failure at the item recognition stage (Barker & Lawson, 1968; Rochford, 1971) which is influenced by familiarity (Oldfield and Wingfield, 1966). This is supported by the finding that allowing participants to handle the objects to be named facilitates naming performance (Appell et al., 1982; Barker & Lawson; 1968). Additionally, Rochford (1971) found that body part naming, covering a range of frequencies but all highly familiar, was vastly superior to picture naming in his patients with possible AD. However, frequency effects in naming have been reported with other stimuli (Kirshner, et al., 1984; Skelton-Robinson & Jones, 1984).

Another influence on naming performance is the quality of the stimuli (Kirshner et al., 1984). To investigate the misperception explanation of naming failure, Kirshner et al. (1984) used four levels of presentation (the object; a black and white photograph; a line drawing; and a masked line drawing). PRAD patients performed worse than a control group on all four presentation types although both groups made more errors with the line drawings and masked presentations. Kirshner et al. concluded that both object perception and word-search are impaired in PRAD. Problems with perceptual processes noticeably influence naming errors in the later stages of the illness (Hodges et al., 1991; Huff et al., 1986).

Explanations of the nature of the underlying semantic deficit in naming follow the "impaired access - degraded store" distinction (Warrington & Shallice, 1979) as outlined above. The majority of accounts see the problem as one of impaired semantic storage (Chertkow & Bub, 1990a,b; Hodges et al., 1991; Henderson, Mack, Freed, Kempler & Andersen, 1990; Huff et al., 1986; Martin & Fedio, 1983). One reason for this is the apparent loss of differentiation between items within a category alongside preservation of superordinate category information (Flicker, Ferris, Crook & Bartus, 1987; Hodges et al., 1991; Martin & Fedio, 1983). This is supported by findings that semantic cueing with a category co-ordinate (such as "it's like a tiger" for "lion") has very little effect on facilitating production of names that cannot be produced spontaneously (Chertkow & Bub, 1990a). Recent evidence from lesioning a connectionist naming model offers further support to the impaired semantic storage account (Tippett & Farah, 1994).

However, other findings suggest that within category distinctions actually remain intact in PRAD (Jackson, Seidenberg, Andersen & Kempler, 1993). Category co-ordinates or attributes, not superordinates, account for the majority of semantically related responses in naming tasks (Bayles &Tomoeda, 1983, Bayles et al., 1990). There is also some evidence that phonemic cueing is beneficial, at least in the earlier stages of PRAD (Funnell & Hodges, 1991; Neils et al., 1988). In addition circumlocutory responses, such as describing the function of an item that cannot be named are commonly reported (Appell et al., 1982; Hodges, et al., 1991; Kertesz, et al., 1986). Thus the naming problem has also been described as reflecting loss of access to the names of items (Hier et al., 1985). Support for this comes from longitudinal analysis of naming performance that, taken with evidence from other measures, suggests semantic representations are retained (Funnell & Hodges, 1991). Confrontation naming performance alone is insufficient for concluding that the speech impairment in PRAD arises from degradation of the semantic store. Indeed, there is evidence that semantic representations are intact, and that the problem arises from a loss of access to specific item names. This can be accounted for if concepts and names are stored separately.

A different sort of naming task requires participants to name famous faces, usually from different decades. This task, commonly used to probe remote memory in patients with retrograde amnesia, is best understood as a test of semantic memory (Parkin, 1993). Unsurprisingly, naming of famous faces in PRAD is impaired (Hodges et al., 1993; Wilson, Kaszniak & Fox, 1981). In one study PRAD subjects claimed to recognise 77% of faces from six decades (1920s -1980s) but spontaneously named only 28% of these (Hodges et al., 1993). Semantic cueing, in the form of an identifying description of the famous person, provided little facilitation to either PRAD or controls, whilst phonemic cueing facilitated naming of a further 28% of names for both groups. There was no difference on a measure of identification, that is subjects providing identifying information about the person they could not name, between the controls and PRAD group, with both identifying an additional 12% of faces. Hodges et al., (1993) interpret the finding that identification was not significantly better than naming as further evidence that the underlying problem in PRAD is with the storage of semantic information. However, the PRAD group performance on this part of the task was the same as controls, suggesting that recognising a face does not necessarily lead to the provision of identifying information. In addition, the facilitatory effect of phonemic cueing suggests that problems in name retrieval could account for at least some of the naming failures.

2.2.4 Naming to definitions

In naming-to-definition tasks subjects supply the name of an item in response to a verbal or written definition. While much less used than picture or object naming, naming to definition has two appealing features. First is that it permits investigation of the influence of input modality on naming. Definitions, based on combinations of functional and associative features, provide an alternative access route to concepts, to visual, perceptually-based stimuli (Caplan, 1992). Second, both abstract and concrete nouns can be examined, whilst visual naming is restricted to the latter. PRAD affects both noun types although the impairment is dramatically worse for abstract ones (Rissenberg & Glanzer, 1987). One possible explanation for this is that the PRAD patients have difficulty understanding the definitions for the abstract words (Nebes, 1989). This may be due to a reduction in verbal memory (Damasio et al., 1990). The range of scores from mild-moderate patients on two 48-item naming tests suggests that definitions (range 6-43) may be more difficult generally than pictures (range 20-48; Huff, Mack, Mahlmann & Greenberg, 1988). However, findings from a severely impaired patient favoured naming to definition (42%) with less than 20% of pictures of the same items named correctly (Funnell & Hodges, 1991). This suggests greater disruption of access to semantic information via the visual representation than via auditory presentation of a collection of semantic features. Despite this, response consistency for both types of stimuli across three presentations of the same items suggests they are valid as alternative measures of the same underlying process (Huff et al., 1988). This reported consistency supports a degraded store account (Huff et al., 1988), whilst longitudinal findings from another study (Funnell & Hodges, 1991), where naming-to-definition was better than picture naming, support impaired access.

2.2.5 Generation tasks

Verbal fluency. These tasks require subjects to generate as many items as possible from a given semantic category or starting with a particular letter. A limited amount of time is allowed for this. Verbal fluency tasks are considered to be a measure of decreased speech spontaneity, indicative of impaired frontal lobe function (Gregory & Hodges, 1993; Stuss & Benson, 1986). The sensitivity of verbal fluency tasks to difficulties in word retrieval may be superior to that of naming (Benson, 1979; Huff et al., 1986), enabling identification of even mild PRAD (Storandt, Botwinick, Danziger, Berg & Hughes, 1984). Peret (1974) suggested that in letter fluency the emphasis is on symbolic factors, whilst category fluency stresses semantic factors.

PRAD patients typically produce fewer items than controls on both letter fluency (Bayles, Boone et al., 1989; Miller & Hague, 1975) and semantic category tasks (Bayles, Salmon et al., 1989; Diesfeldt, 1985; Hodges, Salmon & Butters, 1992; Huff et al., 1986). PRAD subjects generated approximately one third the number of items produced by controls and Korsakoff patients on both category and letter tasks (Weingartner, et al., 1983). PRAD subjects' were equally impaired on both task types using the F.A.S. test (Borkowski, Benton & Spreen, 1967) 'animals' and 'fruit' (Ober et al., 1986). Items produced by the PRAD group on letter fluency were of similar frequency to those of the controls. Similarly, item generation on semantic category tasks follows the pattern of controls with more typical items generated early (Diesfeldt, 1985; Ober et al., 1986). However, Butters et al. (1987) found that PRAD patients performed significantly worse than controls on category fluency, but did equally well on the letter task. The issue is further confused by the findings of Hart et al. (1988) that although PRAD performance was worse than controls on both letters and semantic categories, generation from categories was significantly better than for letters. The disparity in reported results could be the product of different stages of the disease process, with severity affecting performance. For instance, Rosen (1980) found that whilst mild PRAD patients were more impaired on letter fluency, moderate subjects were equally impaired on both tasks. In addition, different letters and different categories do not equate in the ease with which items are generated (Bayles, Salmon et al., 1989; Hart, 1988), thus reducing their comparability. In terms of the discriminatory ability of different verbal fluency tasks, generation from different semantic categories appears to be more sensitive to mild PRAD than letter, first names and supermarket fluency (Monsch, et al., 1992).

Another account for the reduction in performance relative to controls is the slower rate of responding of PRAD subjects (Miller & Hague, 1975). However, Ober et al. (1986) used evidence from the supermarket task (Mattis, 1976) to argue against this. In this task participants are asked to generate as many items found in a supermarket as possible in 60 seconds. Controls typically work systematically through several categories of items, such as fruit and dairy products. PRAD subjects give fewer items from fewer categories than controls (Martin & Fedio, 1983; Ober et al., 1986). They also produce superordinate labels, such as meat, which the controls do not. Ober et al. (1986) argued that if PRAD participants were just slower, although they would get through less categories in the time allotted, the mean number of items per category should be the same. This is because slowing should not interfere with the actual items output, just the number.

Many consider category fluency tasks to be a measure of semantic processing (Huff et al., 1986; Nebes, 1989; Ober et al., 1986). Chan et al (1993) proposed that not only is the semantic network in PRAD impaired but that new and unusual associations develop. They based this proposition on the results of multidimensional scaling and the clustering of responses in a category fluency task. However, Chertkow and Bub (1990a) concluded that category fluency is too complex a task to provide a direct measure of semantic memory. Other factors identified as playing a part in category fluency are attention, control of search strategies, working memory and phonological processes (Bandera et al., 1991; Chertkow & Bub, 1990a; Diesfeldt, 1985; Hodges, Salmon & Butters, 1992).

Free association. In this task subjects are required to output the first word that comes to mind in response to a stimulus word. PRAD patients performed both verbal fluency with a letter and free association significantly worse than depressed or healthy elderly (Grafman et al., 1991). Like patients with dementia from other causes and healthy elderly, PRAD patients are sensitive to grammatical class in word association tasks (Gewirth, Shindler & Hier, 1984). Where stimuli are from different grammatical classes, responses are classified as paradigmatic or syntagmatic, where paradigmatic responses belong to the same syntactic class as the stimulus and have a semantic relationship with it, such as synonyms and category co-ordinates. Syntagmatic responses are from a different syntactic class (e.g. "read" to the stimulus *paper*; Abeysinghe, Bayles & Trosset, 1989). In PRAD, the rate of syntagmatic responses remains fairly constant as severity increases whilst paradigmatic responses decrease and idiosyncratic increase (Abeysinghe et al., 1989; Gewirth et al., 1984; Santo Pietro & Goldfarb, 1985). PRAD subjects commonly give multi-word responses (Abeysinghe et al., 1989; Santo Pietro & Goldfarb, 1985), even though a single word is required. Multi-word responses are common in PRAD and on a measure of naming, the Action Naming Test (Obler & Albert, 1979), they successfully distinguished mild PRAD subjects from healthy controls (Bowles et al., 1987).

Generative associative naming. This is a third type of word generation task, which combines the characteristics of verbal fluency and word association (Bandera et al., 1991). Subjects generate as many items as possible that are semantically related to a stimulus word. PRAD subjects give fewer adequate responses, more idiosyncratic responses and make more perseverations than age-matched controls (Bandera et al., 1991). Responses formed three distinct groupings in this study. One, comprising words with a lower conventionality rate and a higher rate of idiosyncrasies and perseverations, Bandera et al. considered to reflect disrupted access to a relatively unimpaired store. A second group of more conventional responses, maintaining hierarchical-categorical relationships and fewer adequate responses, they interpreted as indicating semantic breakdown. The third and largest group gave both types of responses. Bandera et al.

(1991) concluded that these different response types represent different onset patterns of lexical-semantic impairment that would tend to disappear as degeneration proceeds. As other functional systems are affected the differences disappear, leading to all showing the same patterns of responding.

Finally, in script generation studies, which typically require participants to tell the examiner a sequence of events, such as what they do between getting up and having lunch (Grafman et al., 1991), PRAD participants provide fewer ideas and less information (Grafman, et al., 1991; Weingartner et al., 1983). These deficits occur alongside the preservation of typical and high frequency items. Overall, performance on verbal fluency measures is difficult to explain as the result of either an access or a storage disorder. When combined with Chertkow and Bub's (1990a) caution about the validity of category fluency and the high number of semantically related responses in word association (until greatly deteriorated), these findings suggest that, like naming, evidence from verbal fluency tasks is not sufficient for distinguishing between access and storage problems in PRAD.

2.2.6 Summary

The findings from speech production measures in PRAD present a confusing picture regarding the source of the speech disorder. Spontaneous speech contains less information but the conventions of conversation are preserved well into the deterioration process. Descriptions are likewise lower in information which is interpreted as indicating degraded storage of individual items. Naming performance is impaired, with semantic errors an early characteristic and visual ones increasingly evident as the illness progresses. Phonemic but not semantic cueing facilitates naming, which suggests a loss of access to names. Naming from descriptions may be more difficult than picture naming. Semantic errors in naming both pictures and to description form the highest error group and consistent responses support a degraded store account. On measures of verbal fluency PRAD subjects are slower and produce less appropriate responses than controls. Contradictory findings and the complex requirements of verbal fluency tasks do not allow distinction between storage and access accounts. Overall, evidence from speech production tasks is contradictory with regard to the storage-access distinction. In an account where concepts and names are stored separately, a weakening or loss of links between concepts and their labels would be a possible explanation of these findings. With this account problems finding the name of items is explained as a lexical not semantic problem. This could be the underlying cause, combined with the reduced short term memory capacity and impaired attention found in PRAD.

2.3 Measures of semantic processing

A large variety of tasks have been employed to investigate semantic processing in PRAD. One such measure is semantic priming. It should be noted, however, that some methods used to explore priming in healthy subjects, such as cross-modal techniques, are not easily adapted for use with PRAD groups. Owing to a problem with new-learning (Damasio et al., 1990), PRAD subjects require simple instructions, and need frequent prompting and reminding of the task. Like semantic priming, recognition tasks require less effort than explicit tasks. Recognition measures knowledge both of categories and items, providing a measure of concept information when individual concept names cannot be produced. Providing definitions of words is another method of investigating concept knowledge, by recording the attributes brought to mind in response to a given word. Ranking semantic attributes requires subjects to identify relevant features of target items and place them in order of importance. Sentence completion, or the Cloze technique (Taylor, 1953), requires subjects to provide the final word of sentences that vary in their degree of contextual constraint. This measures the sensitivity of subjects to semantic context. This is also measured by disambiguation of homophones and sentences and sentence correction tasks.

Before describing the findings from the various tasks used to examine semantic processing in PRAD, I wish to consider two methodological issues. The first concerns the comprehension of syntax, as opposed to the production of syntax, which was shown above to be relatively intact. The second is the issue of reading as it relates to carrying out the tasks.

Syntactic comprehension. A number of the tasks reported in this section use sentences as part of the stimuli, particularly measures designed to investigate the utilisation of semantic context. Bayles (1982) reported that PRAD subjects have difficulty recognising syntactic ambiguity. A difficulty understanding complex grammatical structures has also been noted (Kontiola et al., 1990; Tomoeda, Bayles, Boone, Kaszniak & Slauson, 1990). Using a sentence-picture matching task with syntactically varied sentence types Rochon, Waters and Caplan (1994) examined these findings. PRAD subjects performed worse than controls on sentences containing two propositions rather than one, but not on syntactically complex sentences. This further supports the reported preservation of syntactic complexity in PRAD.

Reading. Another skill believed to be preserved in PRAD is reading. Several of the measures used to investigate semantic processing use written stimuli. This reflects the finding that reading aloud is less affected by dementia than other cognitive skills (Cummings, Houlihan & Hill, 1986; Nebes et al., 1984; O'Carroll & Gilleard, 1986), such that a patient who could only spontaneously name 27% of a set of items, could read aloud 93% of the names (Funnell & Hodges, 1991). Two commonly used measures are the Schonell Graded Word Reading Test (SGWRT: Schonell, 1942) and the National Adult Reading Test (NART; Nelson 1982). The former contains words with regular pronunciations and the latter irregulars. The NART was specifically designed to provide an estimate of pre-morbid IQ as it cannot be performed by application of spelling-to-sound rules of pronunciation. Results suggest that reading is preserved until the most severe stages of the disease process (Cummings et al., 1986; Stebbins, Wilson, Guilley, Bernard & Fox 1990) although even mildly impaired PRAD patients perform less well than controls (Fromm, Holland, Nebes & Oakley, 1991).

2.3.1 Semantic Priming

Priming describes a situation in which a response to a stimulus is influenced by an item or event that precedes this response. It can be positive and facilitatory, or negative and inhibitory (Neely, 1991). Priming can be achieved by preceding each item to be responded to with a phonemically or semantically related word. It can also involve the repetition of certain items through the course of the task. Other methods require subjects to rate lists or pairs of words along various dimensions, such as how much they dislike the words (Salmon et al., 1987; Shimamura, Salmon, Squire & Butters, 1987)) or how semantically related two words are (Chertkow et al., 1989; Huff et al., 1988). Measures of priming include lexical decision tasks (Albert & Milberg, 1989; Neely, 1977; Ober & Shenaut, 1988), pronunciation tasks (Balota & Duchek, 1991; Keefe & Neely, 1990), word stem completion (Salmon et al., 1987; Shimamura et al., 1987) and free association (Huff et al., 1988).

Lexical decision. In lexical decision tasks subjects are required to decide whether a string of letters is a real word or not. When speed of lexical decision is the measure of priming, contradictory results have been obtained. Ober and Shenaut (1988), using semantic and rhyming primes, found that the PRAD group were significantly slower than the controls at lexical decision in all conditions, and were slower with semantic primes than when the preceding item was unrelated. Albert and Milberg (1989) obtained similar results. Ober and Shenaut (1988) interpret this as the result of related concepts exerting "hyper inhibition" on the targets. On all other variables - repetition priming, frequency and accuracy of lexical decisions - the PRAD group behaved as the controls. In addition, neither group showed an effect of rhyme priming.

Chertkow et al. (1989) also used lexical decision to investigate priming. In this study, both PRAD and controls showed priming. Whilst Ober and Shenaut (1988) found a slowing in PRAD subjects by a mean of 59 msecs, Chertkow et al. (1989) found a facilitatory effect of between 85 msecs and 266 msecs. The occurrence of 'hyper priming' was confirmed in a subsequent study (Chertkow et al., 1994). Are there any differences between the two studies that could explain this difference in results? In both studies controls improved by about 25 msecs. In both studies subjects responded to all items. In Ober and Shenaut's (1988) study, items were presented 1000 msecs after a response had been given whilst in Chertkow et al.'s (1989) study the gap was 500 msecs. This difference in stimulus onset asynchrony (SOA) could account for the discrepant findings as Ober and Shenaut (1989) reported that with a faster SOA of 250 msecs, they found similar priming effects in their PRAD and healthy elderly subjects.

Chertkow et al. (1989) found the greatest priming effect with target items that they classified as "degraded". As previously indicated, a facilitatory priming effect indicates an access rather than a storage disorder. Chertkow et al. (1989) based classification of items as degraded on longer response times in naming and a probe task making semantic judgements (e.g. 'LEMON', "Is it more like a lime or like a plum?". As they favour the degraded store account they challenged the validity of semantic judgement tasks as a measure of the intactness of semantic memory. However, this does not alter the fact that the large amount of priming they found presents a problem for a degraded store account.

Pronunciation. In two variants of pronunciation tasks priming in PRAD and controls was at a similar level. Balota and Duchek (1991) used word triads of four different types: concordant ("music-organ-piano"), discordant ("kidney-organ-piano"), neutral ("ceiling-organ-piano") and unrelated ("kidney-ceiling-piano"). They found a mean semantic priming effect of 34 msecs (PRAD) and 27 msecs (control) for the second word when the first word was related. Besides producing similar amounts of priming to the controls the PRAD group gave a similar pattern of response latencies to the four types of triad. This suggests that the mechanisms subserving priming are preserved in PRAD.

Nebes et al. (1984) used the more common priming pronunciation task. They had subjects read aloud 80 individually presented words, comprising 40 prime-target pairs. Facilitatory priming was 22 msecs for the PRAD group and 19 msecs for the controls. These findings also support the interpretation of a semantic access disorder (Nebes et al., 1984).

Stem completion. In this task, subjects are provided with word stems, such as 'obs', which they are required to complete to make a word (e.g. 'obstinate', 'obstacle'). In two separate studies using stem completions PRAD patients did not show priming effects (Salmon et al., 1988; Shimamura et al., 1988). In both studies exposure to the primes took the form of a task requiring participants to judge how much they liked a word. PRAD baseline guessing rates at stem completion were comparable with controls and two other patient groups, which suggested that the problem was not due to retrieval failure. In the second task using word pairs that were either categorically or functionally related, baseline guessing again showed no differences between the groups (Salmon et al., 1988). However, the PRAD group showed no effect of priming in this condition either. This lack of priming was interpreted as a breakdown in the actual structure of semantic memory in PRAD (Salmon et al., 1988; Shimamura et al., 1988). However, PRAD subjects have reduced capacity for recall (Bayles & Tomoeda, 1990; Hart et al., 1986; Morris, 1986), thus the lack of a priming effect could result from the gap between presentation of the primes and the priming measure.

Word associations. Huff et al. (1988) investigated priming with a free-association task, performed before and after a semantic-judgement test. The judgement task differed from the one used by Chertkow et al. (1989) with subjects required to decide whether pairs of items go together (e.g. 'bird-wing'). The first item in each pair was a stimulus item in the free-association task. Subjects subsequently had to recall as many items as possible from the three previous tests in a free recall situation. Two measures of priming were obtained. The first was if items from the semantic judgement task were given as responses in the second free-association task. The second was the number of primed responses recalled in the free recall task. PRAD and left-hemisphere stroke patients were equally good at the semantic judgement task. However, the stroke patients showed significantly more priming than the PRAD group. Only three of the eight PRAD subjects showed any priming whilst it was found in all of the five stroke patients. As with stem completion, the reduced recall capacity of PRAD subjects (Bayles & Tomoeda, 1990; Hart et al., 1986; Morris, 1986) could account for the lack of priming effects. Thus these stem completion studies may not tell us anything about the state of the semantic store in PRAD.

To summarise, the evidence from priming studies is inconsistent with regard to PRAD. This firstly suggests that the tasks used are not equivalent. Studies that found no priming are interpreted as indicating a degraded store in PRAD. An alternative explanation is that the gap between presentation of the priming items and the subsequent priming measure was too long. Thus, it is the studies in which priming was found that provide data pertinent to the access-storage question, particularly the large amount of priming found by Chertkow, Bub and Seidenberg (1989) and Chertkow, Bub, et al (1994). Similar patterns of priming using both words and sentences as the primes has been shown to reflect semantic processing rather than arising from intralexical facilitation (Nebes, 1994). Evidence of priming suggests that there is an access problem. In an account with concepts and names stored separately, weakened links between them would mean reduced activation passing from semantic representation to name. Semantic priming would send extra activation from the semantic level to the lexical level.

2.3.2 Recognition tasks

Picture-word matching. In this task subjects are given individual verbal or written labels with a selection of pictures and required to point to the one that matches the label. Alternatives, or distractors, may be semantically related, visually related, phonemically related, associated or unrelated to the target. The choice may be between two pictures, closely matched on one dimension, or a larger selection with distractors of several types. In all guises picture-word matching assesses stored knowledge of a given concept. Error patterns indicate the status of concept knowledge. Within-category semantic errors, visual errors and consistent responses on this measure are interpreted as partial loss of concept knowledge, phonological and unrelated errors as total loss. However, errors on this task do not rule out loss of access or partial or total disconnection between concept and label. Performance on recognition tasks may effectively distinguish PRAD from disorders with similar presentations, where profiles on delayed recall tasks fail to do this (Bayles & Tomoeda, 1990).

PRAD subjects perform as well as controls on between category picture-word matching tasks (Chertkow et al., 1989) until the advanced stages of the illness (Flicker et al., 1987). However, across two presentations (1 week apart) of the Peabody Picture Vocabulary Test, PRAD subjects made inconsistent responses (Knotek, Bayles & Kaszniak, 1990). When all targets and distractors are from the same semantic category, PRAD performance is worse than controls (83%, Chertkow et al., 1989; 90%, Hodges, Salmon & Butters, 1992) but still way above chance level (20% and 17% respectively). Using verbal presentation of a word with a pictured item, PRAD subjects performed worse at identifying associated words for living than non living items (Silveri, Daniele, Giustolisi & Gainotti, 1991). They were also worse at naming the living items (Chertkow & Bub, 1990a; Silveri et al., 1991). This category-specific impairment was also noted by Montanes and Goldblum (1994), who attribute it to the presence or absence of colour in the stimuli, as distinction between living things relies more heavily on colour. However, Hodges, Salmon and Butters (1992) did not find category specific effects in naming in their group of 22 PRAD subjects. In addition, the PRAD group correctly sorted an average of 47.9/48 items into living and non living groups.

Funnell (1993) reported a longitudinal investigation of one PRAD subject across six presentations over two and a half years, using sets of five pictured objects arranged around a written label. The four distractors comprised one near and one far semantic relative of the target, one visual relative and an unrelated item that was a semantic relative of the visual distractor. Word-picture matching performance declined from almost ceiling to chance after two years. At the third and fourth testings, errors were predominantly semantic but this ability to identify the semantic subset deteriorated, so that random errors characterised subsequent performance. Frequency and familiarity had no apparent influence on item failure and there was no discernible consistency in response patterns. This suggests that rather than degradation by loss of specific items, all semantic processes start to disintegrate, with reduced performance resulting from this (Funnell, 1993).

Some studies of picture-word matching require recognition of the written label for a pictured item. Where label selection was between the target and a close semantic distractor 82% of target names were correctly distinguished (Funnell & Hodges, 1991). In a presentation with four written choices, including a category co-ordinate and the superordinate, mild PRAD subjects correctly selected 70% of target names, when they had spontaneously named only 48% (Flicker et al., 1987).

Action-word matching. Subjects match a mimed action with a written or pictured target item presented with a selection of distractors. PRAD patients are significantly worse than controls at this (Benke, 1993; Huff et al., 1988). Analysis of response consistency over two trials suggests that PRAD performance on this task results from loss of actual semantic knowledge (Huff et al., 1988). However, there is evidence that motoric functions are retained after the ability to name and describe the functions of objects is lost in PRAD (Herlitz et al., 1991).

Forced-choice recognition. This is carried out in a variety of ways. For instance subjects are presented with two items and asked to identify which one has a specific attribute (e.g. dog-bird "which one has wings?"; dog-saw "which one is an animal?"). A variant of this is for subjects to answer yes or no to questions about an individual item (e.g. dog - "is it bigger than a house?"). PRAD subjects make superordinate decisions, such as deciding if items are animals, at a comparable level with controls (Chertkow & Bub, 1990a,b; Chertkow et al., 1991; Huff et al., 1986). Performance on specific attribute questions is significantly below controls and is equally impaired with items presented pictorially or verbally (Chertkow & Bub, 1990a,b; Huff et al. 1986).

A further variant is the method adopted by Huff et al. (1988). For each item subjects answer "yes" or "no" to a question that correctly defined the item, one that defined another item from the same category and a third defining an item from a different semantic category. On this task PRAD patients scored 94% correct, significantly worse than controls. One particularly interesting finding from these studies is that 10% of items judged to be intact on a forced-recognition semantic probe measure could not be named correctly (Chertkow & Bub, 1990a). This was interpreted to indicate that the semantic judgement task is not a reliable measure of semantic representations. This is because Chertkow and Bub see a degraded semantic store, which contains an item's name, as the underlying disorder in PRAD. Thus, loss of an item's name has to be interpreted as indicating a degraded store. However, this finding is much easier to explain if names and concepts are stored separately. Either the actual name can be lost, or the links between the concept and the name can be lost or at least weakened.

Category recognition. Diesfeldt (1985) required subjects to read aloud four item names and make a category decision about them. On one trial subjects had to decide which was the name of a fruit and on a second trial which was the name of an item of clothing. PRAD subjects scored 100% correct. This finding is particularly interesting as the recognition task was preceded by a generation task using the categories fruit and clothing. On this not only did the PRAD subjects produce significantly fewer items than controls, some subjects produced no examples at all. These findings taken together suggest that category information is intact and available in PRAD but is inaccessible by some routes.

Category recognition was also tested by Bayles et al. (1990), alongside category recall. Following confrontation naming of 13 items, subjects had to supply the category name from which the items came. They then selected the category name from four printed choices. This category recognition task was much easier to perform than either naming or category recall. The majority of errors were selection of the semantic distractor, which challenges the idea that attribute knowledge is lost while category knowledge is maintained (Bayles et al., 1990)

Category sorting. A further recognition task is the category sorting of Hodges, Salmon and Butters (1992). Subjects sorted 48 drawings first into living or non living, then at the superordinate level (e.g. birds or water animals) and thirdly, two categories - land animals and household objects - were subdivided on attributes. At the highest level, PRAD subjects performed on a par with controls. On superordinate and subordinate sorting PRAD performance was 88% and 87% respectively, whilst controls recorded 96% correct on both.

Evidence from recognition tasks is therefore also inconclusive regarding the access-storage issue. PRAD patients are able to distinguish between items from different categories, but less able to distinguish between items of the same category. This suggests loss of access to defining attribute information. However, lack of longitudinal consistency in responding, and the tendency to select semantic distractors rather than superordinates challenges this. If semantic representations of concepts and their lexical referents are stored separately, then weakening of links between them could account for these findings. The stored representation may remain intact until well into the deterioration process.

2.3.3 Defining items

Providing definitions of items from the word, either written or spoken, is often used to examine knowledge for items that cannot be spontaneously manipulated. The ability to produce definitions is influenced by word frequency, which determines comprehension (Warrington, 1975). In one study, whilst only 25% of pictures were spontaneously named, over 75% of those not named were adequately defined (Funnell & Hodges, 1991). Compared to age-matched controls, PRAD subjects produce significantly less factual information about items that they define (Hodges, Salmon & Butters, 1992). One feature regularly reported is the superordinate label of the item (Hodges, Salmon & Butters, 1992). This has been interpreted as reflecting apparent loss of specific item knowledge thus supporting the degraded store explanation of the underlying semantic disorder in PRAD. However, PRAD performance on the WAIS-R vocabulary scale is within average age levels (Martin & Fedio, 1983). Instructions for scoring definitions on this test state that the general classification, or superordinate category, to which an item belongs (the example is "a penny is a coin") is worthy of full marks. Therefore on this measure, providing superordinate information is not only a desirable response, it is taken to signify intact functioning. In addition PRAD subjects adequately defined a selection of words for which they failed to provide related words in a word association task (Abeysinghe et al., 1990). This was interpreted as loss of associative links between concepts rather than loss of actual concepts, echoing the suggestion of Appell et al. (1982) that in PRAD links between words and other words and words and concepts are lost.

2.3.4 Semantic attributes

Another approach to studying concept knowledge is to examine what subjects know about the attributes associated with a concept. In a study using an aetiologically mixed dementia group, Grober, Buschke, Kawas and Fuld (1985) examined their subjects' ability to correctly identify attributes associated with a concept. Overall, the dementia subjects correctly identified 95% of target attributes. This may, in part, be due to their tendency to say "yes" to more attributes than controls, thus also selecting more foils. Abeysinghe et al. (1990) looked just at the attribute knowledge of PRAD subjects. A target word was presented along with four other words, each on separate cards. Participants judged which of the four accompanying words was most closely related to the target, then the next most, through all four. Of the four words, three were related to the target, ranked in order of production frequency in associative tasks and the fourth was unrelated. PRAD participants were worse than controls at identifying the most related and the unrelated items. Within the PRAD group, mildly impaired patients were better able to distinguish these than moderately impaired. This suggests a weakening of links between attributes and labels as PRAD progresses.

2.3.5 Sentence completion

Using highly contextually constrained sentences, PRAD subjects correctly completed significantly less than Korsakoff amnesics (Weingartner et al., 1983), depressed elderly

(Grafman, et al., 1991) and elderly controls (Grafman et al., 1991; Weingartner et al., 1983). However, in both studies incorrect PRAD responses were semantically and logically related to the sentence, suggesting retained ability to utilise semantic information.

Further evidence of this is the finding that speed of sentence clozure is influenced by the degree of constraint. This influences both control and PRAD subjects (Nebes, Boller & Holland, 1986) with a greater effect on the latter. Indeed PRAD completion of high-constraint sentences was an average of 800 msecs quicker than low-constraint ones, compared to 200 msecs for controls (Nebes et al., 1986). In a follow-up study Nebes and Brady (1991) adapted the sentence completion task to examine effortful processing in PRAD patients. Participants judged whether a word shown to them following auditory presentation of a sentence appropriately completed the sentence. As in the previous study, PRAD subjects were influenced by contextual constraints in the same way as both young and older controls. High-constraint sentences were responded to quicker than medium-constraint, which in turn were quicker than low-constraint. As with other tasks, sentence clozure appears to be influenced by severity, such that a severely impaired subject was only able to provide 14% of targets in a sentence clozure task (Funnell & Hodges, 1991). These findings indicate that the ability to utilise semantic context remains until the disease process is severely advanced.

2.3.6 Disambiguation and anomaly

Another measure of usage of semantic context is subjects' ability to disambiguate homophonic words (e.g. 'night' and 'knight'). Homophones may be presented in a disambiguating sentence or a list of related items. In two studies comparing the ability of PRAD patients to use semantic or syntactic context to disambiguate words, performance on both was impaired relative to controls (Cushman & Caine, 1987; Kempler, Curtiss & Jackson, 1987). However there were far more errors on the semantic trials, although this requires cautious interpretation as controls also showed less accuracy with semantic context, even though their performance was near ceiling. This suggests that utilising semantic context is more difficult than syntactic context and that PRAD subjects' performance reflects the general deterioration in cognitive processes.

The detection and correction of anomalies and other errors, which also provides a measure of the utilisation of semantic context, may also be more difficult than sentence clozure. Semantically, syntactically and phonologically incorrect sentences were used by Bayles (1982). She found that whilst PRAD subjects performed worse than controls on all three types, their inability to correct semantically anomalous sentences (such as "I lost John's temper") was the most successful measure at discriminating the two groups. However, in another study, both PRAD and controls successfully detected most errors and there were members of both groups who performed at ceiling (Kempler et al., 1987). These contradictory findings are difficult to interpret, but may reflect differences in severity in the patients reported.

2.3.7 Summary

Measures of semantic processing in PRAD present further confusing and contradictory findings. Among priming studies, semantic priming at normal, increased and decreased levels, as well as no priming have been reported. Whilst there is some reduction in performance on within-category discrimination recognition tasks, this remains well above chance levels until the disease process is severely advanced. In addition, there is no apparent loss of subordinate information with differential preservation of superordinate knowledge. Whilst subjects offer reduced information in descriptions of items, they can apparently define words for which they cannot generate relatives. The reduced quantity of information available is reflected in their lowered ability to identify and rank semantic attributes. However, utilisation of semantic information is preserved to the extent that it is used in completing sentences. Utilising semantic information to disambiguate and correct anomalies may be a more difficult task, which is thus more impaired in PRAD.

Thus semantic knowledge appears to be largely intact in the face of differentially preserved ability, relative to task difficulty, to carry out semantic tasks.

2.4. Subgroups and separable disorders

There are clearly discrepancies and contradictory findings in the many studies considered above. Differences in severity among subject groups can explain some of these. Another explanation may come from the recent detailing of subgroups in PRAD. These are described as distinct presentation profiles of PRAD, with focal rather than global impairments, that deteriorate over time into the classic, global pattern of AD. In addition, at least three separate disorders have been recently described which were previously subsumed under the PRAD label. These are described as distinct syndromes that retain their focal profiles through the course of the illness.

The different functional patterns being identified in PRAD reflect the uneven distribution of neuropathological changes in AD. Cortical atrophy is greater in temporal, parietal and frontal association areas with sensory and motor areas relatively spared (Brun & Englund, 1981; Chase et al., 1984; Chawluk et al, 1990; Damasio et al, 1990; Haxby, Duara, Grady, Cutler, & Rapoport, 1985; Martin, 1990). Evidence from autopsy (Martin, 1990), and studies of cerebral blood flow (Celsis et al., 1990; Hagberg & Ingvar, 1976) suggest that hemispheric involvement is asymmetric (Celsis et al., 1990; Chawluk et al., 1990). Subcortical changes are most prevalent among limbic structures (Brun & Gustafson, 1978), particularly the hippocampal formation, the entorhinal cortex (Adelstein et al., 1992; Damasio et al., 1990) and the amygdala (Damasio et al., 1990). The functional changes seen in PRAD reflect this neuropathological selectivity. Failure of episodic memory is related to hippocampal and association cortex damage (Damasio et al., 1990). Impairment on semantic memory tasks is associated with left temporal damage (Coughlan & Warrington, 1978; Marin, Glenn & Rafal, 1983; Patterson, Graham & Hodges, 1994; Wilkins & Moscovitch, 1978; Zaidel & Rausch, 1981). Disturbed attention and concentration and difficulty grasping new tasks whilst retaining competence at well-practised ones are indicative of frontal lobe damage (Rylander, 1939). Failure in resource allocation and supervisory control of attention is blamed for these behaviours (Baddeley, 1986; Shallice, 1982). In addition, frontal lobe damage results in reduced initiation of spontaneous speech (Stuss & Benson, 1986), disruption of retrieval processes (Kopelman, 1991) and problems with self-monitoring (Kleiter & Schwarzenbacher, 1989; McNamara et al., 1992).

While the neuropathology of PRAD does not affect the brain evenly, most areas are involved to some extent. Thus we would expect the degree of impairment in PRAD patients to differ from patients with focal damage. Functional impairments reflect the relative degree of involvement of the implicated brain region. For instance, monitoring of stored general knowledge is apparently intact in PRAD until the advanced stages (Bäckman & Lipinska, 1993; Shimamura & Squire, 1986) although there is reported frontal lobe atrophy in PRAD. The subgroups and particularly the separable disorders described below illustrate the variation of regional involvement in neuropathological changes. Certainly in the latter there is evidence of circumscribed damage through the course of the degeneration process. This is one compelling reason for distinguishing them from PRAD.

2.4.1 Subgroups

Several recent reports have detailed profiles of subgroups within PRAD (Bandera et al., 1991; Becker et al., 1988; Martin, 1987, 1991; Martin et al., 1984; Neary et al., 1986). In some of these biopsy and autopsy data have confirmed the presence of AD (Martin, 1990; Neary et al., 1986). Martin et al., (1985) initially excluded from their analysis two groups of patients who showed focal, rather than global, patterns of deficits on neuropsychological testing. One group had, in the authors' terms, preserved semantic/lexical ability in the face of impaired episodic memory and visuospatial and constructive function. The other group had normal visuospatial and constructive abilities and impairment on the semantic/lexical and episodic memory tasks. The third group, the largest and the one initially reported, showed impairment in all three domains. Martin et al. (1985) referred to this third group as globally impaired. The group with semantic/lexical impairments showed glucose hypometabolism in the left temporal region and the visuoconstructive group in the right parietal. The globally impaired group had bilateral temporoparietal hypometabolism. Following the delineation of Martin (1990), Goldstein et al. (1992) investigated performance of the three subgroups on a naming task. Goldstein et al. (1992) varied the frequency and visual complexity of the picture stimuli and found frequency affected all groups. The group with visuospatial impairment were slower than controls and the group with semantic/lexical impairment made more semantically related errors than either the visuospatial or severe globally impaired groups. Becker et al. (1988) reported three groups with similar distinguishing features. On subsequent testing the patients in the focal groups exhibited decline in all cognitive functions, with initial problem areas worse affected (Becker et al., 1988; Martin, 1990, Martin et al., 1985).

These findings are of particular interest in relation to the language disorder of PRAD for the following reasons. First, if such subgroups exist, they could account for the variety of features noted in descriptions of PRAD. Thus the confusion and contradictions may be due to there being more than one presenting profile. Second, such subgroups may explain the existence of both perceptual and semantic disorder accounts of the noted naming problem in PRAD. Thus, in some individuals, naming problems may arise from problems with semantic/lexical information, while in others it may arise from misperception of the stimuli. In the globally impaired majority, it may be due to an interaction of problems with both perceptual and semantic/lexical processes. The third reason follows from the other two and is that the naming disorder associated with PRAD is a direct result of the existence of these subgroups. In the majority of studies, results are reported for PRAD subjects without differentiation. In the process of averaging across data, a naming disorder may be apparent that is attributed to all cases when it only exists in some. In other words, individuals in the two focal groups may have problems with naming which are skewing the results. In studies where all subjects are classed as PRAD, the naming disorder would be attributed to all cases. This can reconcile the apparently contradictory reports of some observers of severe problems with naming and of others noting only minor disturbance.

2.4.2 Separable disorders

The influence of separable disorders on our understanding of the language disturbance of PRAD has close links with the subgroups just discussed. This is because identifying separate disorders could account for some of the diverse symptoms reported in PRAD. Three main disorders have been described. The first is primary progressive aphasia (PPA), introduced by Mesulam (1982). He presented six cases of a non-fluent speech disorder unaccompanied by general cognitive decline. Five of the six complained initially of an increasing anomia, later accompanied by impaired reading, writing and comprehension. In the face of this relentless language deterioration, their reasoning, memory and visuospatial abilities were within the normal range, and they retained insight into their condition and normal daily living skills. In four at least, the signs of generalised dementia did not emerge in follow-up testing between five and eleven years post-onset. The focal nature of the functional disturbance led Mesulam to propose PPA as a clinical entity distinct from PRAD.

Since Mesulam's initial report, many additional cases have been presented and debated. Pogacar & Williams (1984) reported a case with similar features that was confirmed at autopsy as AD. Two further cases (Wechsler, Verity, Rosenschein, Fried & Scheibel, 1982; Holland, McBurney, Moossy & Reinmuth, 1985) had similar profiles to those of Mesulam's but were found at post-mortem to have the neuropathological changes associated with Pick's disease. PPA has also been referred to as a presentation variation of AD (Poeck & Luzzatti, 1988), with patients going on to show global decline (Green, Morris, Sandson, McKeel, & Miller, 1990). However, PPA differs from the subgroups described above because it has a much slower and persistently focal pattern of deterioration. In addition, the speech of PPA sufferers contains large amounts of phonemic paraphasias (Mesulam, 1982) but no circumlocutions or evidence of perceptual errors in naming (Weintraub et al., 1990). Support for differentiation from AD comes from the findings of focal atrophy of the left temporal lobe and/or perisylvian structures among the cases that have reached autopsy (Gregory & Hodges, 1993; Holland et al., 1985; Mesulam, 1987; Wechsler et al., 1982). In addition positron emission tomography (PET) has revealed glucose hypometabolism in the left temporal lobe and computed tomography (CT) left perisylvian atrophy in PPA patients (Chawluk et al., 1986). Although Pick's bodies and cells have not been consistently reported in PPA cases, it is very close to the original case of progressive decline with marked speech disorder described by Pick (1892; Hodges, 1993).

In contrast to non-fluent PPA, where Broca-like features emerge, semantic dementia (SD; Hodges, Patterson, Oxbury & Funnell, 1992; Snowden et al., 1989) is a progressive aphasia with fluency retained. PET, CT and magnetic resonance imaging (MRI) all reveal temporal lobe involvement (Gregory & Hodges, 1993). The features of this disorder are severe anomia, impaired single-word comprehension, reduced general knowledge and poor performance on category fluency tasks (Hodges, Patterson et al., 1992). The reading patterns associated with surface dyslexia, specifically impaired reading aloud of exception words and preserved regular pronunciations are another noted feature (Hodges, Patterson et al., 1992; Patterson et al., 1994; Patterson & Hodges, 1992). Phonology, syntax, perceptual skills and episodic memory are preserved (Hodges, Patterson et al. 1992). This profile is interpreted as the result of a selective impairment of semantic memory (Hodges, Patterson et al. 1992).

Both SD and PPA have anomia as the most prominent feature, but they clearly differ in several ways. In SD, cerebral alteration is focused on the temporal lobe, while in PPA, there is more widespread left hemisphere involvement (Chawluk et al., 1986; Gregory & Hodges, 1993). In PPA, spontaneous speech is non-fluent and contains many phonemic paraphasias. In SD, speech is fluent, phonology is undisturbed and paraphasias are semantic. Hodges, Patterson et al. (1992) suggest that in the past, SD was most probably subsumed with Pick's disease. There is certainly recent evidence of a patient with fluent, progressive anomia in whom Pick's disease was confirmed at autopsy, and whose anterior temporal cortices were most affected (Graff-Radford et al., 1990). However, it is likely that many cases were previously labelled PRAD. Indeed, the primary disturbance of semantic processing accords well with the majority of accounts of the language disorder of PRAD (Bayles, 1982; Chertkow & Bub, 1990; Hodges et al., 1991; Martin & Fedio, 1983). Thus there is the possibility either that SD is another subgroup of AD, or that it is the semantic/lexical subgroup identified by Martin (1990) and by Becker et al. (1988). Hodges, Patterson et al. (1992), however, consider SD to be distinct and separate from PPA and from PRAD, whilst its relationship to Pick's disease remains to be clarified (Gregory & Hodges, 1993; Hodges, 1993; Patterson et al., 1994).

Both PPA and SD are relevant to defining the language disorder of PRAD in a similar way to the subgroups outlined above. It seems likely that the profiles of each have previously been included in the overall description of the language disorder of PRAD (Gregory & Hodges, 1993). This confounding of them all may account for some of the conflicting and confusing signs. In addition, the presentation of SD challenges the accepted notion of the underlying disorder of PRAD being semantic. This is because the inclusion of SD cases in PRAD studies, may have lead to the averaged data appearing as a semantic problem.

As SD and PPA may account for some of the temporal/semantic impairment reported in PRAD, so dementia of the frontal type (DFT; Gregory & Hodges, 1993; Orrell & Sahakian, 1991) may be responsible for some of the frontal signs. Alterations in personality and social interactions, disinhibition and neglect of personal hygiene and self-care may all occur in DFT (Gregory & Hodges, 1993). DFT patients show a lack of insight and awareness of others; speech output may decline and be marked with perseveration (Gregory & Hodges, 1993). DFT matches the original description of a patient with focal frontal lobe degeneration (Pick, 1906) and illustrates the fractionation and confusion surrounding primary degenerative dementias.

Following the detailed case studies at the end of the last century and the early years of this one, there was a considerable decline in interest in the clinical profiles of the degenerative disorders in the US and UK (Hodges, 1993). It was during this time that global impairments attributed to AD became the diagnosis of default. With the revival in interest has come the description of 'new' disorders. It is becoming increasingly apparent that these are often profiles that have been seen before. As AD became seen as the major cause of primary degenerative dementia, so Pick's disease (PD) was considered a rare occurrence. However, Pick described several different cases and the neuropathological changes associated with his name, were actually identified by Alzheimer (1910-1911). These changes do occur rarely and if diagnosis of PD requires them, then it too must occur rarely. However, it seems that the disorders now being distinguished from PRAD are among the profiles Pick described of focal frontal and temporal atrophy. Once again the varied patterns of preservation and impairment are being charted, 100 years after Pick (1892) described his patient with focal language impairment and general cognitive decline.

2.5 Summary

Disordered speech in PRAD presents a confusing picture. As PRAD is a degenerative disorder, speech profiles change over time. Outlining a clear picture of the effect of PRAD on speech is made more difficult by the interaction of severity and pre morbid individual abilities. Among the features included in descriptions of speech disorder in PRAD are some which may belong to other, more focal, disorders. Most prominent among these are PPA, SD and DFT, which may be newly described, or may be rediscoveries of earlier descriptions. In addition, there is growing support for the idea of presentation subgroups occurring in PRAD, prior to global decline.

An underlying semantic disorder is often proposed as the cause of disordered speech in PRAD. Evidence is interpreted to support either a degraded semantic store or disordered access to an intact store. The data, however, do not fit easily into these two explanations.

Indeed, the validity of the criteria for distinguishing between them and even for drawing such a distinction, have been questioned (Caplan, 1992). An additional query over these two semantic accounts arises from the very evidence they try to explain. For instance, when locating the name of an item is a problem, this is interpreted as a semantic disorder because names are held to be stored in semantic memory. Even if a subject can describe an item, recognise the category it is from and produce close semantic relatives, the problem is described as semantic. A more obvious explanation is that the problem is with the names rather than the concepts. Thus, individual item names could be lost. Or, links between concepts and names could be affected. If concepts and their names are stored separately, the number of possible impairments increases. However, this is particularly appealing in a degenerative disorder, where increasing severity progressively erodes the normal processes. This allows for variation between individuals in speed and pattern of breakdown and accounts for data that purely semantic explanations have difficulty with.

Chapter 3

Language processing and speech production

In this chapter I will review the evidence for two- rather than one-stage models of lexical access in speech production. In particular, I examine the ability of different models to cope with speech error and neuropsychological data. I also consider the arguments for whether the processes involved in lexicalization are separate and discrete or interacting. A third issue examined is whether input and output processes use the same or different lexicons. The storage and retrieval implications of current models of production are also considered. These issues are particularly important for investigating the claims that the underlying disturbance in PRAD is semantic. Two-stage models of speech production have separate levels of representation for semantic and lexical items. This enables discrimination between problems with the accessing and storage of concept knowledge (semantic representations) and problems with the labels for such concepts (lexical representations). The chapter ends with consideration of a previous attempt to explain speech production in PRAD with a two-stage model (Blanken et al., 1988). In this the two stages are serial rather than overlapping. In comparison I also present an interactive activation two-stage model. I generate predictions from this to explore the competing hypotheses and language profiles of PRAD presented in Chapter 2.

3.1 Studying speech production

Language comprises the three components of acquisition, comprehension and production. Of these, production is comparatively more difficult to study than the other two (Dell, 1986; Garnham, 1985; Garrett, 1980). The two main methods for studying speech production (Garrett, 1980) are direct experimentation and the collection and analysis of spontaneous speech samples. Many researchers favour the latter, with theoretical accounts based on analysis of conversations, patterns of hesitations and spontaneous speech errors (Levelt, 1992).

A third, older method of studying speech production, is the documentation and interpretation of cases of impaired performance. The early work of people such as Broca and Wernicke in the late Nineteenth Century concentrated on localization, the mapping of functions to specific areas of the brain. They did this by studying individuals with abnormal production, generally acquired as a result of head injury rather than through developmental disorders. They related abnormal functions directly to the damaged area(s), with fuller exploration at post-mortem.

On its own, this methodology has limitations and for a long time experimentation and analysis of unimpaired speech samples were preferred. However the rise of cognitive neuropsychology has restored abnormal functioning to its traditional position as a major source of information. The reason for this is two-fold. First, ideas about normal functioning can provide explanations for what goes wrong in disorders. Second, disorders can further our understanding of normal functioning Thus, studying the language disorder in PRAD not only explicitly requires explanation from current models of normal functioning, but also implicitly allows examination of the ability of these models to deal with disorders.

3.2 Different models of speech production

When we wish to say something, we initially start with thoughts and ideas of what is to be said. Selection of the precise meaning, or semantic specification, follows. We must then select the words that go with the meaning and retrieve the phonology. Finally, we articulate the words. The translation from semantic specification to phonological word form is known as *lexicalization*. The main questions about this process are: How many stages are there? Are the stages independent or do they interact? Is the lexicon used for speech production also used for comprehension or are there separate lexicons? For clarity I use the terms semantic level, phonological level and lexicon when referring to all of the models, rather than those used by individual authors. The semantic level is where concept information is stored. The phonological level is where phonological word forms are stored. The lexicon is where words are to be found.

Throughout, my concern is with production of content words. In models that also address function words these are found in a different computational vocabulary (Blanken et al, 1987; Bock, 1982; Garrett, 1984; Stemberger, 1985).

3.2.1. How many stages?

There are thought to be either one or two stages to lexical access. With the one-stage account, translation between semantic and phonological processing is direct. In such models lexical items are stored as either semantic or phonological information. Models with both these arrangements have been proposed to account for a variety of information. I first review the evidence for lexical storage at the semantic and phonological levels and explore the ability of these models to account for other data. Following this I consider the explanatory power of so-called two-stage models, in which lexical items are stored separately from either semantic or phonological information.

Words at the phonological level. Based on analysis of word substitution errors, Fay and Cutler (1977) proposed a model of speech production with lexical items effectively stored at the phonological level (see Figure 3.1). In their account word meanings are portrayed as combinations of semantic and syntactic features. These are used to extract the appropriate word from the lexicon. Fay and Cutler describe the lexicon as comprising sound-meaning pairs which are ordered phonologically. This characterisation arose from certain features of the target-error pairings they studied. Their analysis was of malapropisms, whole word substitutions which share certain phonological features with the target but do not have any similarity in meaning. In the following example from Fay and Cutler (1977) and in all subsequent others T is the target utterance and E the erroneous output:

(1) T: If these two vectors are equivalent, then...

E: If these two vectors are *equivocal*, then...

Malapropisms and targets are usually from the same grammatical category, share the same stress patterns and mostly have the same number of syllables (Fay & Cutler, 1977). The phonological similarity between targets and substitutions, in the absence of semantic similarity, combined with the guiding principle of optimising accessibility to the lexicon, led to their description of a phonologically ordered lexicon. In addition, parsimony underlay their conclusion that this lexicon is used for both production and comprehension (see section 3.2.3. below).

Fay and Cutler argued that malapropisms could not be explained if the lexicon is organised semantically, that is by meaning-relationships between words. They also argued that the lexicon does not need to be arranged semantically to explain semantic errors, such as examples (2) and (3) from Fromkin (1971):

(2) T: This room is too damn cold.

E: This room is too damn *hot* - cold.

(3) T: the written part of the exam.

E: the *oral* - written part of the exam

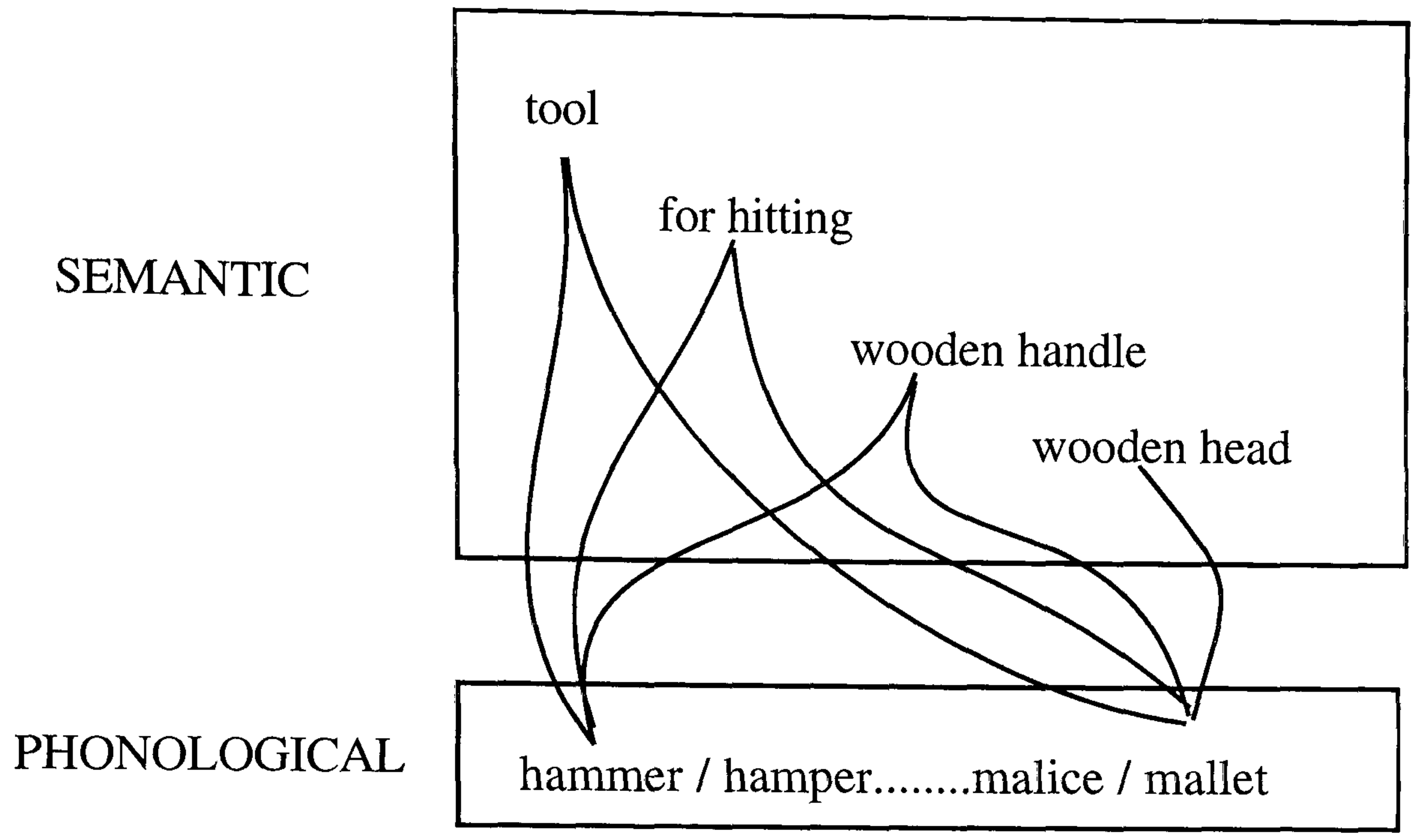


Figure 3.1. One-stage model with words at the phonological level, based on Fay and Cutler (1977) .

Fay and Cutler suggest that semantic errors could arise from either an underspecification or a slight mistranslation of the semantic specification, such that a semantically related word is output. However, a further class of errors, so-called mixed errors, cannot be satisfactorily explained with Fay and Cutler's model (Harley, 1984). Mixed errors are those where the substitution is a word both semantically and phonologically related to the target, such as examples (4) and (5) below, taken from Harley (1984).

(4) T: electronic

E: *electric*

(5) T: chromatography

E: *crystallography*

Owing to the arbitrary nature of the relationship between meaning and sound, mixed errors should only occur by chance in Fay and Cutler's model (Harley, 1984). Semantically related items will not be close to each other in the phonologically organised lexicon. However, a far greater number of these semantically and phonologically related errors occur than would be predicted by chance (Dell & Reich, 1981; Harley, 1984). This undermines the claim for a phonologically ordered lexicon (Harley, 1984).

Further evidence against the lexicon being at the phonological level is the TOT state. One feels strongly that the word has been selected but the phonological form is somehow underspecified. Partial phonological information is regularly available, as are relatives of the elusive target (R. Brown & McNeill, 1966; Koriat & Lieblich, 1974; Lovelace, 1987; Rubin, 1975; Yarmey, 1973). If the lexical item and phonological word form are the same, it is difficult to explain how only part of the word is available if it is successfully located. The model that can explain whole word semantic or phonological substitutions, is insufficient for explaining mixed errors and TOT responses.

Words at the semantic level. One model which has been proposed to account for TOTs, and which also takes account of some of the factors constraining word substitutions, is the *Node Structure Theory* (NST; Burke, MacKay, Worthley, & Mann; 1991) of speech production. In this connectionist model, words are part of the semantic level and are thus separate from phonological word forms (see Figure 3.2). TOTs are explained by the *Transmission Deficit* hypothesis, which states that items at the phonological level receive insufficient activation to become output. The strength of the connections between the semantic and phonological levels is influenced by word frequency so that higher frequency items have stronger connections. This in part explains the finding that low frequency words are more often targets in both TOTs and substitution errors than are high frequency items (Harley, in press; Stemberger, 1984). Retrieval in this model is by syntactic class and thus erroneous responses are from the same class as their targets. Activation spreads through this model, with items related to the target receiving some activation. Therefore errors with similar meanings, similar sounds and both similar meanings and sounds should occur.

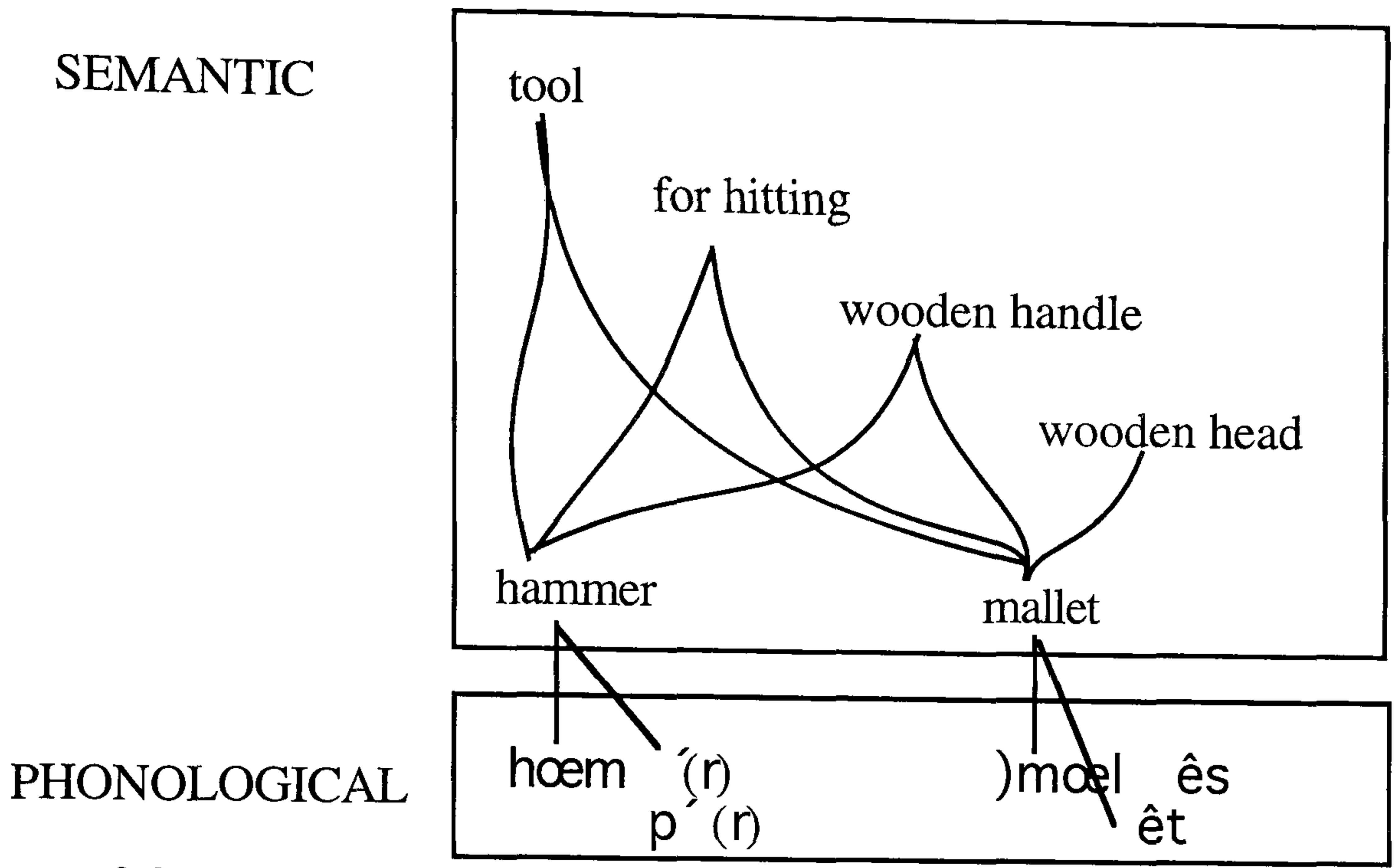


Figure 3.2. One-stage model with words at the semantic level based on Burke et al. (1992).

Siting the lexicon at the semantic level can account for TOT and speech error data that is troublesome for models with the lexicon located at the phonological level. However, certain neuropsychological data suggest that lexical items are also stored separately from semantic information. Patients with semantic but not lexical impairment, with lexical but not semantic impairment, and with phonological but not semantic or lexical problems all support the separation of concepts and labels, in addition to supporting the separation of words and phonological word forms, as proposed above. Patient KE (Hillis, Rapp, Romani & Caramazza, 1990) made semantic errors in reading, writing, naming and comprehension. The similarity of his errors across input and output modalities was interpreted by Hillis et al. (1990) as a result of impaired semantic information. Another patient with an apparent semantic disruption is JCU (Howard & Orchard-Lisle, 1984). She produced a pattern of semantic errors and cued responses that indicated an impairment of her semantic information. JCU made errors both in naming and comprehension and had difficulty rejecting semantic co-ordinates as incorrect target names. Production of lexical items was significantly increased with phonemic cueing. This pattern of performance, including impaired comprehension, suggests insufficient or deficient semantic information or weakened connections between semantic and lexical items as the cause of her semantic errors. Another patient with apparent semantic but not lexical disruption is WLP (Schwartz et al., 1979) who could read aloud words, including ones with exceptional spellings, but she had no idea of their meanings. This suggests an intact lexicon disconnected from semantic information.

In contrast to WLP, patient HK (Allport & Funnell, 1981) could not produce any intelligible speech and performed at chance level on lexically-mediated tasks, such as word-picture matching. On non-linguistic tasks, though, such as playing board games and finding a route, he performed at normal levels and functioned otherwise normally. HK's profile is suggestive of intact semantic processing independent of lexical knowledge. Additional cases of apparently intact semantic processing and impaired lexical processing are patients RGB and HW (Caramazza & Hillis, 1990). They made numerous semantic errors whilst displaying intact comprehension performance. Their conceptual knowledge was apparently unimpaired which is difficult to explain if words are part of semantic information. The account Caramazza and Hillis propose is a failure in word retrieval. This explanation is based on the word superiority effect in repetition and the inconsistency in production from one session to the next noted in these patients.

Further evidence for the separation of semantic and lexical information is from a personal account of a transient ischemic attack (TIA) causing transient anomia (Ashcraft, 1993). He describes six incidents that occurred during a 45 minute period marked by word-finding difficulty and preserved meaning. Ashcraft states clearly that his thoughts and ideas were fluent and normal. He was, however, unable to express hardly any of these thoughts. Unlike TOT states, he had no partial information about the words that he could so clearly "think". Similarly Wender (1989), in a personal account of her recovery of spoken language following a left temporal cardio-vascular accident (CVA), describes how she did not have the words to express what she so clearly thought. In contrast to Ashcraft's transient attack, Wender documents recovery over several years. A Classics professor, both Latin and Greek were reduced to a few letters and names following the

CVA. She decided to work on relearning Greek but ignored Latin. Examined at 3 years, her Greek was very good with Latin still missing. To rule out spontaneous recovery, she studied 10 unknown Latin words and ignored 10 unknown Greek words for a week. At testing, the Latin but not Greek words were known. Most significantly, Wender points out that when she thought of the experiment and how to run it, the words to express it were unavailable - she learnt them to write a draft of the article.

EST (Kay & Ellis, 1987) also demonstrated an understanding of the items he was unable to name. Rather than semantic errors however, his output consisted of more TOT-like responses, with partial phonological information for the target word available. He was able to word-picture match and reject close semantic relatives of unnamed pictures and close phonological nonwords. The items he was able to name were of higher frequency than those he failed to name. Like the TOTs they resembled, EST's problems were attributed to a failure to retrieve the phonological word form for the target lexical item.

The evidence from the above neuropsychological profiles offers strong support for the separation of semantic and lexical items. KE (Hillis et al., 1990), JCU (Howard & Orchard-Lisle, 1984) and WLP (Schwartz et al., 1979) demonstrate impaired semantic and preserved lexical processing. HK (Allport & Funnell, 1981), RGB and HW (Caramazza & Hillis, 1990) on the other hand present with lexical impairment and preserved semantic processing. This is supported by the personal accounts of Ashcraft (1993) and Wender (1987). Finally, EST (Kay & Ellis, 1987) demonstrated an understanding of the items he could not name and made primarily phonological errors. His case offers additional support for the separation of lexical from phonological representations.

Words stored independently. The evidence from a variety of neuropsychological cases suggests that words are stored independently from concepts. That is the lexicon is separate from the semantic level. In addition, TOT and speech error data suggest that lexical items and their phonological forms are stored independently. Thus, the lexicon and phonological levels are also separate. To account for these data requires a speech production model with separate semantic, lexical and phonological levels. In two-stage accounts, abstract word forms are stored at a separate, lexical, level (see Figure 3.3). Processing passes from semantic through lexical to phonological. The first stage, then, is the specification of a phonologically abstract lexical item or *lemma,* an abstract, syntactically specified package (Garrett, 1992; Kempen & Huijbers, 1983; Levelt, 1992). The second, stage is the accessing and retrieval of the appropriate phonological word form, also containing morphological information (Kempen & Huijbers, 1983; Levelt, 1992). This two-stage formulation is widely accepted in speech production research (Bock, 1987; Butterworth, 1989; Dell & O'Seaghdha, 1992; Garrett, 1992; Harley, 1990; 1993; Harley & MacAndrew, 1992; Levelt, 1989, 1992; Levelt et al., 1991; Martin, Weisberg & Saffran, 1989; Schriefers, 1990; Schriefers, Meyer & Levelt, 1990. See Levelt, 1992, for a review).

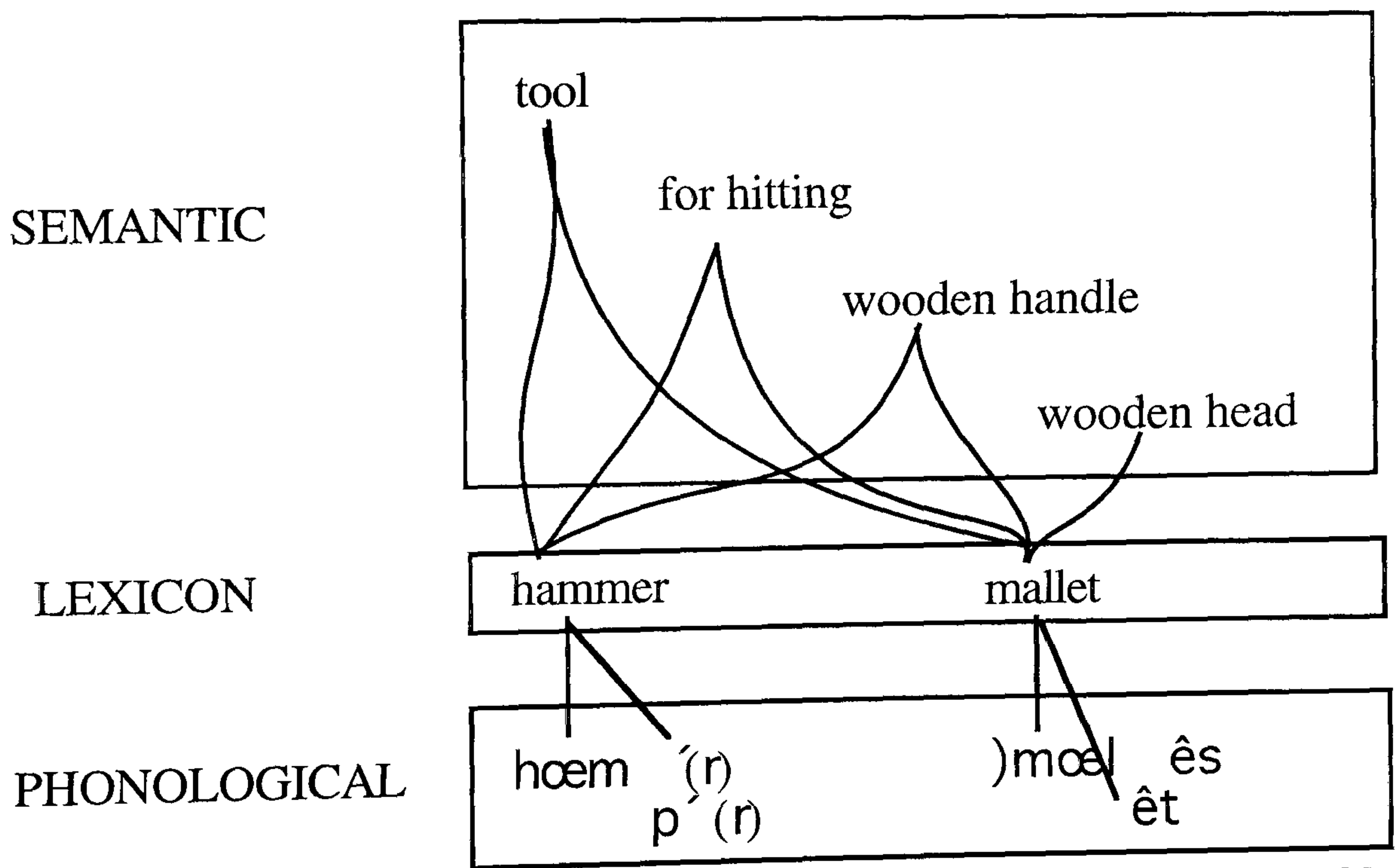
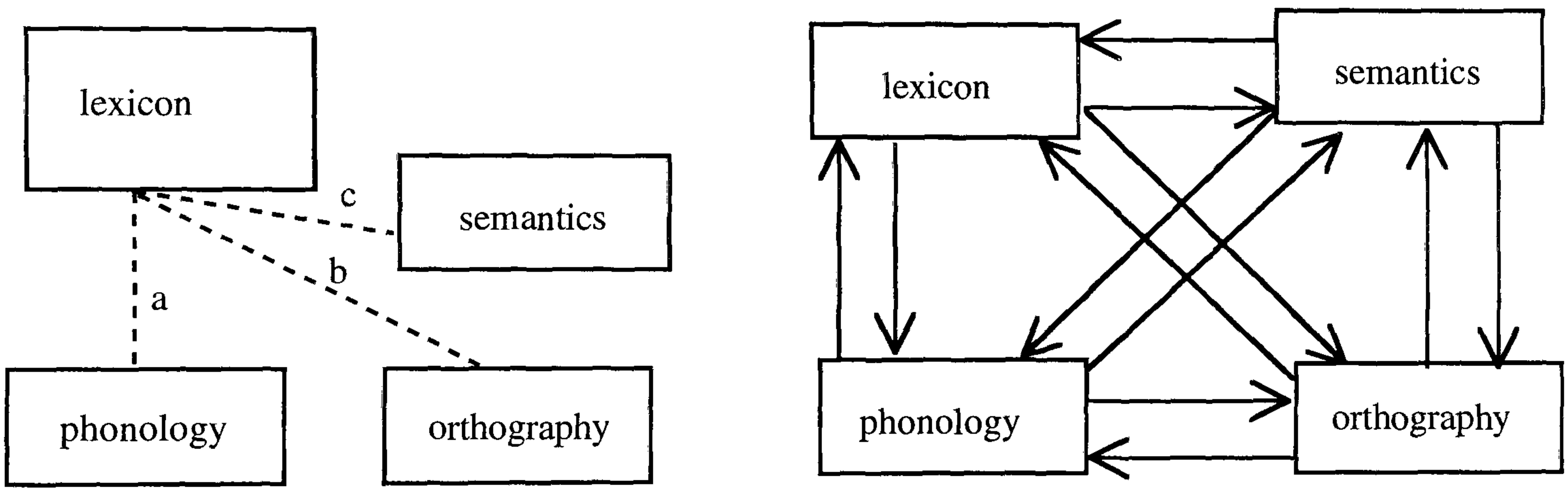


Figure 3.3 Two-stage model with separate lexicon, based on Harley (1991, 1993, 1994).

The "double look-up" hypothesis was originally proposed to account for speech error data. Kempen and Huijbers (1983) showed that this two-stage approach could also be applied to naming, where recognition and word retrieval processes had traditionally been linked, with no separate lexical stage (e.g. Oldfield & Wingfield, 1964, 1965; Seymour, 1979). Evidence from repetition priming also supports the separation of words from both their meanings and phonological forms (Monsell, 1985). Also the experimental work of Levelt and his co-workers (Levelt, 1989, 1992; Levelt et al., 1991; Schriefers, et al., 1990) has added further supporting evidence (see also 3.2.2 below). In addition, our ability to deal with homonyms and synonyms, to identify as words items whose meaning we have forgotten or never knew, plus knowing words that have no meaning, such as portmanteau words, have all been cited as further evidence for representation of lexical items separate from semantic and phonological (Monsell, 1985). The two-stage approach has also been used to explore aphasic speech. Martin, Saffran and Franklin (1990) studied the malapropisms made by two Wernicke's aphasics using a two-stage model and concluded that such errors are best understood as lexically-driven. That is, they arise from activation passing to phonological relatives of the target at the lexical level of representation. Similarly Blanken et al. (1987) and Blanken (1990) present an analysis of Wernicke's aphasic substitutions using a model with two-stage lexical access. A similar two-stage model was used by Harley and MacAndrew to provide an account of neologistic jargon aphasia (1991) and paraphasias, whole word substitutions made by normal and aphasic speakers (1992; see also Harley 1993).

Evidence against separate storage of words. Before ending this section I would like to address some additional neuropsychological data which have previously been presented against a separate lexicon containing words. Allport and Funnell (1981) contended that models with such a single lexicon could not account for the semantic reading errors of deep dyslexics, the disorder of word-meaning deafness and the specific spoken-written word matching problems of conduction aphasia. Deep dyslexics produce a spoken word that is semantically related to the printed stimulus. This strongly suggests that they progress from spelling to sound via a semantic route. A model containing a separate lexicon such as Forster's (1976) serial search model or Morton's (1969, 1970) early version of the logogen model, where the lexicon mediates between all other processes, could not explain these semantic errors (see Figure 3.4 a). Patients with word meaning deafness fail to understand spoken words, but can speak and write fluently, write to dictation and repeat aloud. This profile suggests direct translation between phonology and orthography without, they suggest, mediation by a lexicon. A third source of evidence against a separate lexicon is patient AL (Allport & Funnell, 1981), a conduction aphasic. He could select correctly the written label to match a spoken word and select which of two written words was closest in meaning to a spoken word. He could not match a spoken nonsense syllable to its written label or select the correct written label for a spoken word from two closely related labels (e.g. "dress-frock"). As with word-meaning deafness, AL's pattern of results requires direct translation between phonological and orthographic codes, a process not compatible with Figure 3.4a.



(a) (b)

Figure 3.4. Two models with separate lexicons. (a) is based on Allport and Funnell (1981), with the lexicon as mediator: (b) has connections between each component.

However, these neuropsychological arguments against a separate lexical store can be addressed with an alternative model, such as that in Figure 3.4b. This model allows for the semantic mediation of reading found in deep dyslexics and for direct translation between phonological and orthographic codes. It should be noted that distinguishing orthographic and phonological word forms is common to many commentators (Allport & Funnell, 1981; Caplan, 1992; Ellis & Young, 1988; Ferrand & Grainger, 1994; Grainger & Ferrand, 1994; Funnell & Allport, 1987). This does not necessarily have a bearing on their opinions about the existence of a separate, amodal lexicon, containing word-information from all modalities (see 3.2.3). It should also be noted that subsequent versions of the logogen model contained several logogens for each word, rather than a single mediating one (Morton, 1979). The model in Figure 3.4b also fits with the preceding data which argues for the separation of semantic, phonological and lexical items in speech production.

3.2.2. Are the stages discrete?

Working on the basis that speech production contains two stages a question currently attracting much interest is whether the lemma stage is completed before the word form stage is embarked on or whether there is simultaneous activity at both the lemma and phonological levels. *Discrete* theorists believe that word form retrieval only occurs when lemma retrieval is complete. *Cascade*, or interactive theorists hold that the two stages overlap. If the latter is correct, then phonological processes should have some influence on lemma selection. Much of the evidence on which these models are based is from speech errors in normal speakers.

Garrett's (1975; 1976, 1980) influential hierarchical model, made up of four levels, was developed from analysis of speech error data. He considered the levels to be independent and for activity to pass down from the highest (message) level, through two syntactic levels, functional followed by positional, finally reaching a phonemic level. This is an early example of a discrete model with activity passed down only when the processing at a level is completed. The current major proponents of the discrete model of lexicalization are Levelt and his colleagues (Levelt, 1989, 1992; Levelt et al., 1991; Schriefers, et al., 1990).

There are certain types of speech error that present problems for models such as Garrett's. For instance evidence that the message level can intrude on lower levels to produce errors (non-plan internal errors - Harley, 1984). In addition there is the role of phonology in (i) word substitution errors and (ii) the facilitation of non-plan-internal errors. In addition, such models have difficulty explaining the lexical bias effect in speech errors (Dell & Reich, 1981), this is the tendency for substitutes to be real words rather than jargon utterances. Additionally, the noted word superiority effect in speech errors, this is the tendency of speakers to produce real words as erroneous output rather than strings of phonemes or unconnected syllables, is difficult to explain with a serial model. Such findings suggest that there is some interaction between the levels. For instance, phonological facilitation errors suggest interaction between the message level and the phonemic level, and the word superiority effect can be explained by interaction between the functional and phonemic levels. It was largely to explain these types of errors that interactive, or cascade, accounts of lexicalization developed.

In an attempt to distinguish between the discrete and interactive accounts, Levelt et al. (1991) carried out an experiment looking for what is termed *mediated priming* (Dell & O'Seaghdha, 1991). This is where phonological relatives of semantic relatives of the target will receive some activation, which is measured through response times. In other words, if the target is "sheep", semantic relatives, such as "goat" are primed. Is this then, at phonological word form selection, passed on to phonological relatives of goat, such as "goal"? Levelt et al. argued that cascade accounts predict the occurrence of this mediated priming whilst discrete models do not. The experiment involved picture naming and concurrent auditory lexical decision. They found that whilst semantic neighbours ("goat") of the pictured item ("sheep") were responded to quicker, there was no such effect with phonological relatives of semantic neighbours ("goal"). In a separate experiment (Schriefers et al. 1990) it was shown that "sheep" only has a priming effect for "goat" (semantic relative) early in the naming task, whilst phonological relatives, such as "sheet" are primed later in the task. From such data, Levelt et al. (1991) and Schriefers et al. (1990) concluded that the lemma stage, when semantic relatives are available, is completed before the word form stage, when phonological relatives are available.

The predictions attributed to interactive models by Levelt et al. (1991) were challenged by Dell and O'Seaghdha (1991). They also argued that mediated priming would not necessarily occur, as very little, if any, activation would be passed on to the phonological specification of semantic neighbours, let alone to their phonological neighbours.

Subsequently, Harley (1993) has shown that the findings which apparently provide evidence against interactive models, can be explained by just such a model. Through the use of simulations, he produced results consistent with those of Levelt et al. (1991). Harley (in press) has shown that local features such as imageability and frequency, which are hypothesised to influence lemma retrieval and word form retrieval respectively, can be explained with a cascade model whilst retaining the ability to explain, among other things, mixed errors in speech. In addition, data on the effect of the frequency of orthographic neighbours on visual lexical decision and pronunciation is most compatible with a model using parallel, rather than serial, search (Grainger, 1990).

3.2.3. How many lexicons?

In arguing for the separation of lexical items from both semantic and phonological representations, the model presented above (see Figure 3.3) contains one lexicon. However, in section 3.2.1 the focus is on lexicalization in speech production. The question of how many lexicons we have broadens the discussion to include input as well as output. Basically, are there separate lexicons for comprehension and production of speech? This question is one that arises when considering the profiles of people with PRAD as well as other neuropsychological and experimental data. In addition, the same question applies equally to orthographic representations and I shall extend the discussion to consider both types of representation. Indeed, so many of the tasks below are cross-modal that it is difficult to explore phonology and orthography separately.

The question of whether input and output processes use the same lexicon is complicated by various factors. The first difficulty is terminology. This refers to the use of the term *lexicon* by different authors. To answer the question of how many lexicons there are, it is vital to establish what component of cognitive processing is being referred to. For instance, some authors use the term to refer to the stores of phonological and orthographic components of language. The second complication arises from theoretical bias. Answers to the question differ depending on whether they derive, for instance, from one- or two-stage models. This interacts with terminology, such that two-stage models contain a separate word-store lexicon. One-stage models either have the lexicon as part of the semantic level or containing both words and phonological representations (see 3.2.1 above). The third complication are data, which interact with the other two. Attempts to derive equivalency from the various approaches to this question necessarily include consideration of the data underlying them. In this section I consider some of the approaches adopted to answer this question. No definitive view is attempted as my concern is with highlighting some of the difficulties underlying this question.

One-stage model with four lexicons. Accounts favouring the separation of input and output processes, which contain a one-stage lexical access, typically have four lexicons (Ellis & Young, 1988; Monsell, 1985, 1987; Morton & Patterson, 1980; Patterson & Shewell, 1986; see Figure 3.5). They correspond to input phonology and input orthography, output phonology and output orthography . The case for such a model is comprehensively argued by Ellis and Young (1988).

Monsell (1985) presented three pieces of evidence for the separation of input and output representations. First are the findings of Shallice, McLeod and Lewis (1985) of very little interference on dual-task performance of visual word naming and auditory stream monitoring for the same words. Second, are some of Monsell's own experiments where in an auditory lexical decision task both saying the words and mouthing them produce more priming than seeing or writing them because, he argues, they activate the full articulatory programme of the words. Third, there is evidence from conduction aphasia (McCarthy & Warrington, 1984; Morton, 1980) for a dissociation between speech input and output.

Further evidence for the separation of input and output representations comes from explorations of lexical facilitation in picture naming (Morton, 1979; Warren & Morton, 1984; Winnick & Daniel, 1977). Warren and Morton (1984) used four conditions to separate the effects of recognition and uttering the name on speed of subsequent naming. These were naming the same pictures in both pretest and test conditions, naming different pictures with the same name in the two conditions, reading the name in the pretest and naming the picture in the test and naming different pictures with different names in the pretest and test. They found the same-same condition was quicker than the other three, than the same name-different picture at the 5% level and the other two at the 1% level. Reading the name in the pretest was the same as the control (different-different) condition. Thus speaking the item beforehand had no facilitatory effect on subsequent speed of naming. This lack of cross-modal priming is interpreted as support for the existence of separate representations.

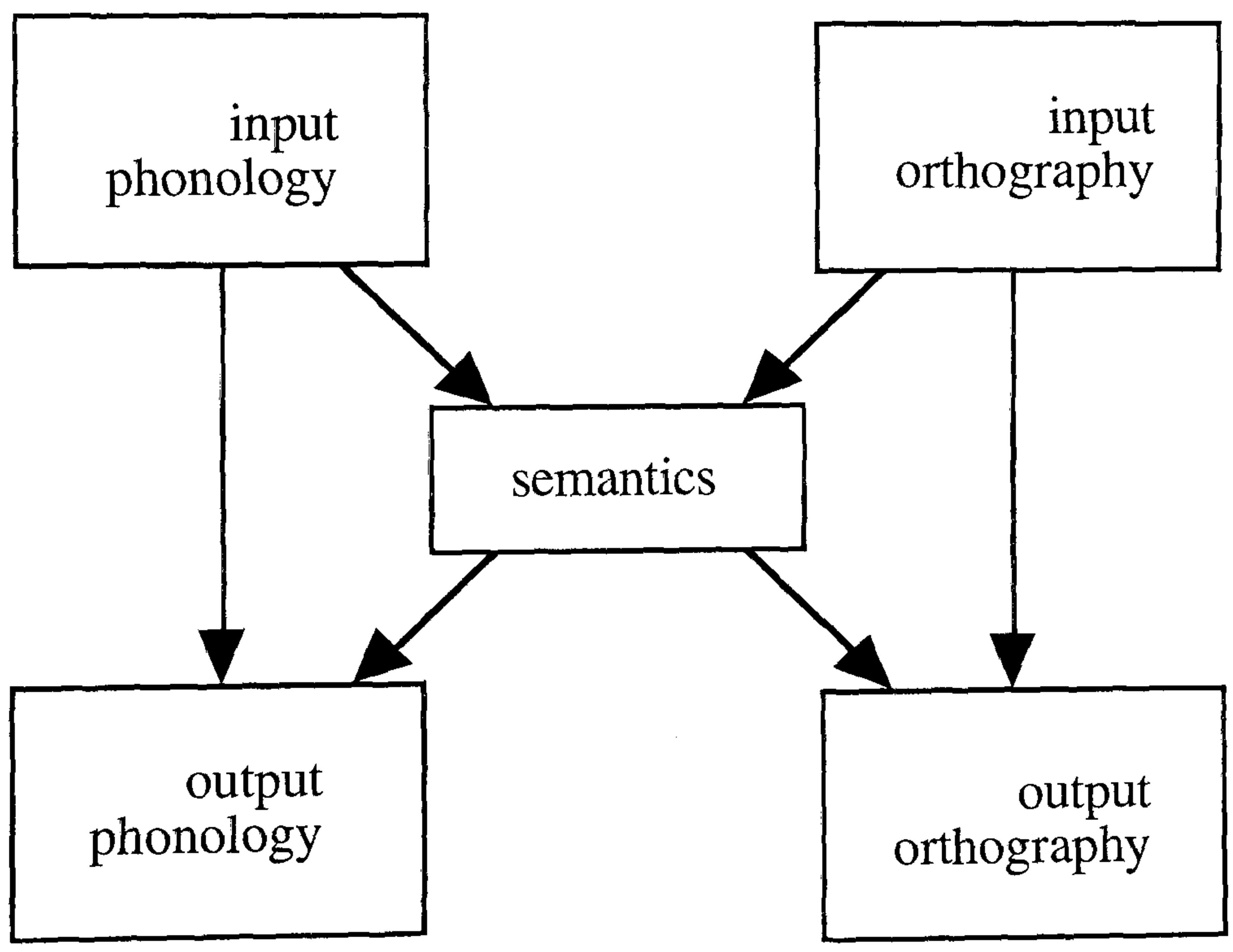


Figure 3.5. Model containing separate representations for input and output processes (after Allport & Funnell, 1981).

One-stage model with three lexicons. Campbell (1987a) makes the case for an amodal phonological store, accessed by a variety of means, including lip-reading, mouthing and hearing, which she likens to Monsell's (1987) "phonological input buffer" (p131). The implication is that there is a comparable store of phonological representations to serve output tasks. In addition, Campbell (1987b) argues for the separation of input and output orthographic representations. She bases her arguments on the findings of a lexical decision task using two subjects' own mis-spellings. Campbell found that they were worse at rejecting mis-spellings when mixed in a list with nonwords. She argues that the best explanation derives from an account with separate stores for reading and spelling (Campbell, 1987a).

One-stage models with two lexicons. In these models input and output processes share a single lexicon, with one for listening and speaking and one for reading and writing. Firstly, on grounds of parsimony both Fay and Cutler (1977) and Allport and Funnell (1981) propose a single lexicon for both speech comprehension and production. Allport and Funnell (1981) also consider orthography to have a single lexicon used for both and reading and writing (Figure 3.6). Whilst conceding that optimal access for both comprehension and production may require separate lexicons, Fay and Cutler (1977) contend that avoidance of duplication is a stronger motivator and thus propose a single lexicon.

Coltheart and Funnell (1987) examined the prediction that with a single lexicon for reading and writing, equivalent impairments should occur, in an attempt to distinguish between the two lexicon/four lexicon arguments. Establishing that their patient, HG, had reading and spelling difficulties arising at the level of orthography, they found two pieces of evidence in support of a single orthographic representation for both processes. First that in both reading and spelling frequency produced similar effects. Second that HG was better at spelling words he read correctly than words not read correctly.

Evidence from conduction aphasia may support the separation of input and output representations in speech processes (Monsell, 1987). However, Allport and Funnell (1981) interpreted the performance of their patient AL, a conduction aphasic, within a two lexicon model. He performed poorly at object naming and well at picture-word matching, which could be taken as evidence for the separation of input and output lexicons. However, his preserved ability to read aloud the names of items he could recognise but not name suggests one store (Allport & Funnell, 1981). In the same paper the problem of word meaning deafness, interpreted above as supporting the four lexicon approach (Ellis & Young, 1988), is addressed within the two lexicon model (Allport & Funnell, 1981; see section 3.2.1 above).

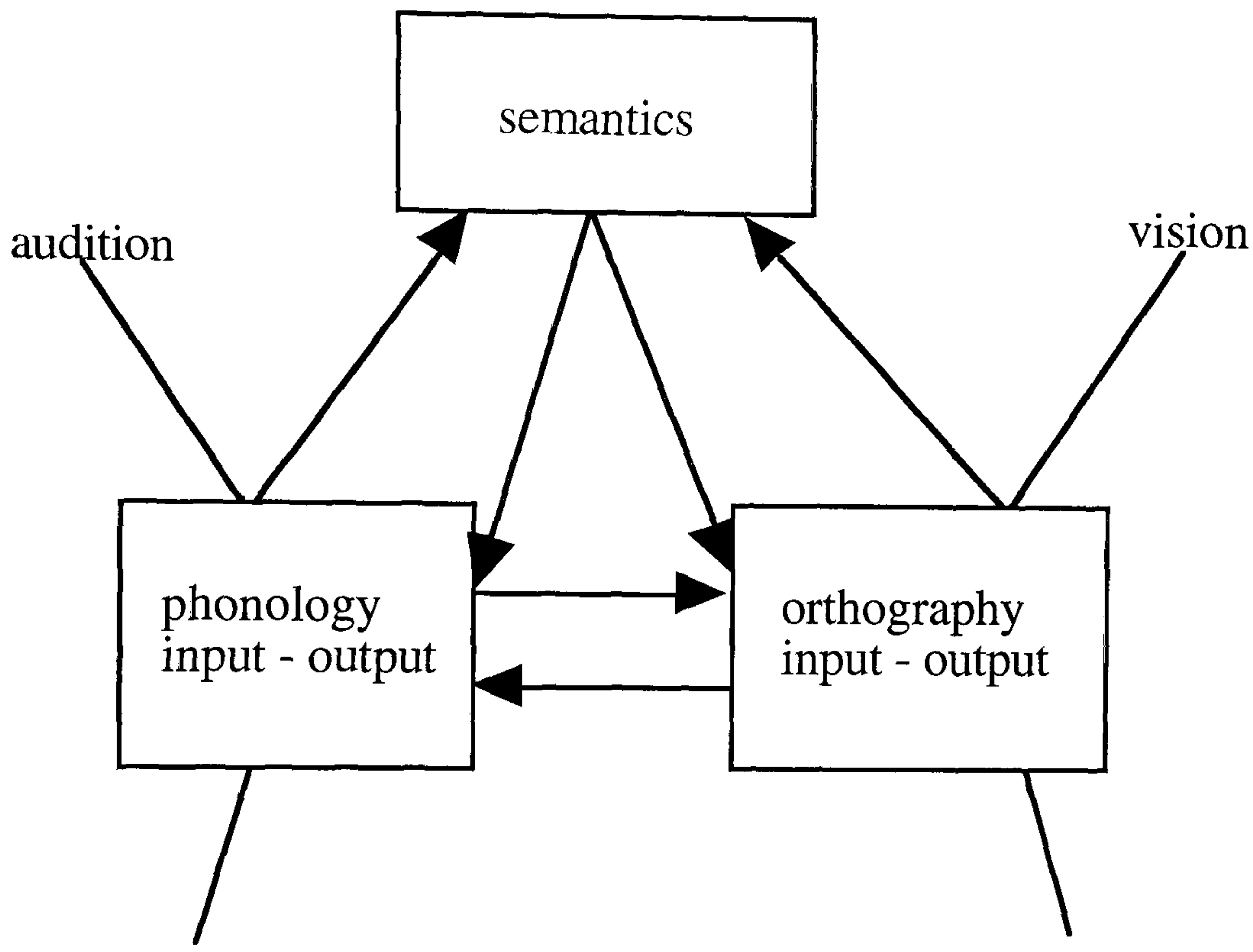


Figure 3.6. Model with one set each of phonological and orthographic representations for input and output processes (after Allport & Funnell, 1981).

Allport and Funnell (1981) also argue against the significance of the lack of lexical facilitation on picture naming (Warren & Morton, 1984) as support for separate input and output representations. They suggest that more convincing evidence would be the lack of a repetition effect on subsequent spoken word recognition or no effect of writing a word on subsequent visual recognition. In the face of these being demonstrated, they argue that the two lexicon model could still explain the results by reference to the access pathways (see figure 3.6). Thus facilitation applies to processes using the same pathways and does not transfer to other processes using the same lexicons via alternative routes.

Two-stage models with separate input and output lexicons. The arguments considered above derive from models with one stage between semantic representation and phonological or orthographic representations. With regard to two-stage models, the question of how many lexicons there are becomes two part. First, are there separate word stores for input and output processes and for phonological and orthographic processes? In effect do reading, writing, hearing and speaking have access to four separate word storing lexicons? Second, are there separate stores of phonological and orthographic representations for input and output processes? That is do reading and writing make use of the same or different orthographic representations and equally do hearing and speaking use the same phonological representations?

With reference to the first question there are two-stage models of speech production which have separate lexicons for input and output (Butterworth 1989, Levelt, 1992). In Levelt's terminology these are the "word recognition lexicon" and the "active production lexicon". These models do not address reading and writing but in principle it follows that there would be two further lexicons, one for each process. Figure 3.7 represents this approach.

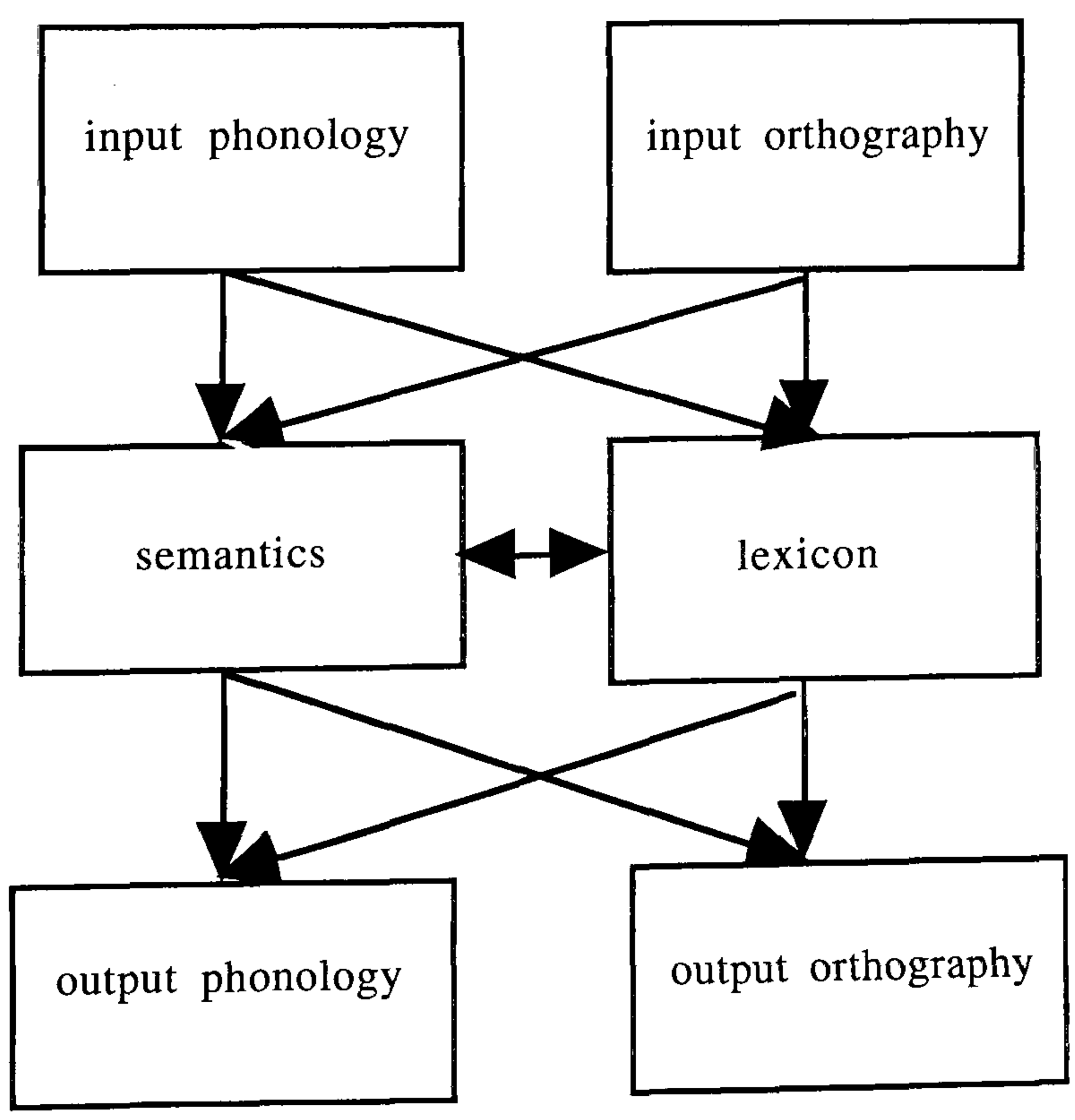


Figure 3.7. Model with separate storage of lexical items and input and output phonological and orthographic representations.

Two stage models with one lexicon. On grounds of parsimony, if no other, there is an argument for having a single, amodal lexicon. A store of words accessed by all tasks with a lexical component, with separate pathways for each type of input. In addition, the argument made by Allport and Funnell (1981) regarding the specificity of priming to tasks using the same access routes, is also applicable. For instance the finding that reading aloud an item's name does not increase speed of picture naming is taken to support separate representations (Warren & Morton, 1984; see above). Why should previously speaking the name facilitate the picture recognition part of the task? In the same name-different picture condition, prior production of the name is in response to a picture. This condition is slower than the same-same one because the picture is different. However, the picture has some features shared with a previously seen picture and so is quicker than the two conditions where no picture or a picture with a different name have been seen before. Thus the picture recognition aspect appears to be the crucial element in this task, not prior utterance of the name. Thus the lack of cross-modal priming reported in some studies may not be a problem for a model with a single, amodal lexicon.

I now turn to the second question posed above. That is whether input and output processes use the same or different representations. In two stage models these processes are sublexical. There is certainly supporting evidence for the idea of shared representations for speech perception and production in the notion of listeners as re-articulators (Prinz, 1987; Studdert-Kennedy, 1987). There is also a suggestion that listeners and speakers represent the message passing between them in parallel (Porter, 1987). That is, that both speaker and listener simultaneously represent the message passing between them. The implication of this is that heard and spoken speech are represented in the same way (see Figure 3.4, section 3.2.1 above).

As to evidence supporting separate storage, that proposed above in consideration of one-stage models could still largely be used to argue for separation within two-stage models (see Figure 3.7). At this time, it seems cases can be made for both shared and separate storage of phonological and orthographic representations. Perhaps evidence from PRAD can help resolve this debate.

3.3 Speech production in PRAD

Goodglass (1980) proposed that retrieval of an item's name requires adequate activation of the concept. One explanation for reduced activation is that the concept representation is degraded. This is the degraded store account of semantic impairment underlying the language disorder of PRAD. However, as demonstrated in Chapter 2, not only is the evidence from naming tasks inconclusive regarding the access/storage debate, when evidence from other tasks is considered, it is difficult to provide a satisfactory account using either explanation. Thus a model with separate storage of concepts and labels is suggested.

One previous attempt to study speech in PRAD is that of Blanken et al. (1987). They studied the spontaneous speech of PRAD patients within a comprehensive model of speech production. Their model includes a pre-linguistic planning stage, a formulation stage including the processes of lexicalization and grammaticalization, and an articulatory, output stage. In this model lexicalization contains two parts. First is the identification of "lexical meanings', that is the semantic specification. Second is the location of "lexical forms" or words. They concluded that in spontaneous speech the primary disturbance in PRAD is at the pre-linguistic content-planning stage. They found little evidence of a word retrieval difficulty in spontaneous speech although they did note reduced production of nouns.

In addition, Blanken et al. (1987) showed that PRAD patients made many semantic paraphasias and visually related errors in a naming task. They also noted that in formal test situations word finding difficulties are more apparent (Blanken et al., 1987; Stengel, 1964). As they concentrate on spontaneous speech data, Blanken et al. (1987) do not offer an explanation for these findings. Indeed they conclude that the lexicalization apparatus is largely intact in PRAD. However, their findings of poor naming performance and the word finding problems outlined in Chapter 2, must be accounted for.

In an attempt to address all of these data, I use the two-stage interactive account of lexicalization outlined in Chapter One (Harley, 1990, 1991, 1993, 1994: Harley & MacAndrew, 1992). Within the framework of this two-stage model there are several possible explanations for the speech disorder in PRAD. The data reviewed in Chapter 2 suggest that the impairment rises at the lemma stage rather than with phonological processing. That is retrieving the abstract lexical item is the problem. Therefore the consideration of possible explanations will be restricted to four. First, that the semantic representations of items are impaired but not completely lost. As a result, an item with a similar semantic specification to the target may receive activation and its lemma be retrieved. Second, that the links between semantic and lexical stores may become weakened. Thus the contact between concept and label is increasingly unreliable and eventually lost. Third, that the lemmas themselves may be damaged or lost. If damaged their availability would be unreliable. If lost they would, of course, be unavailable. Fourth, that the inhibitory connections operating at the lexical level may be lost. This would lead to competing items not being restrained.

The experiments described in the following chapters are an attempt to address the issue of which explanation, if any, of the above is most likely. The focus of these experiments is on speech production and in particular lexicalization. However, where the data address other aspects of language processing, such as input representations, discussion will include these.

Chapter 4

Participants

The focus of this thesis is on patients with probable Alzheimer's disease (PRAD). The participants were drawn largely from the assessment ward and day centre of a local psychiatric hospital. As far as possible, participants were followed to new accommodation if they moved. Over the three years, 58 people were approached to take part. Of these 16 moved away before completing all measures and 15 died. A further 4 were excluded for having previous psychiatric history and 5 were so deteriorated at initial contact that they could not take part.

The majority of the participants meet the criteria of the Work Group of the National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and the Alzheimer's Disease and Related Disorders Association (ADRDA; McKhann et al, 1984) for having probable AD (PRAD). This designation is commonly used among researchers, as confirmation of AD is only reliable at autopsy and will be used from hereon, except when referring to autopsy- or biopsy-confirmed AD. In addition, PRAD participants had Hachinski scores of 4 or less (Hachinski et al., 1975). Diagnoses were made by a Consultant Psychiatrist based on history, toxicological and serology screenings and reported course of deterioration. Appendix I contains details of the 19 people with PRAD who took part in at least one experiment. They range in severity of deterioration from mild to severe, with Mini-Mental State scores ranging between 4 and 22 (see Appendix I). All participants showed deterioration in all areas of functioning including time and place disorientation, episodic day-to-day forgetting, reduced insight and increased disability in self care. None showed patterns of focal impairment at testing, suggesting they matched the global impairment subgroup identified by Martin et al., (1985). In addition, data were collected from control subjects matched with the PRAD subjects for age and education. (see Appendix II).

4.2.1 Background data

In addition to collecting the experimental data, I also administered a number of standard neuropsychological tests. These data were collected at the same time as Experiments 3, 4, 5 and 7, and so are only available for participants who took part in these experiments. These include the Mini-Mental State Examination (MMSE, Folstein et al., 1975) and the Clifton Assessment Procedure for the Elderly (CAPE, Pattie & Gilleard, 1979) to confirm the presence of dementia and give a guide to the severity. In addition I administered an auditory and visual lexical decision task, synonymy triplets from the Philadelphia Comprehension Battery for Aphasia (Saffran, Schwartz, Linnebarger, Martin & Bochetto, 1989), the Boston Naming Test (BNT; Kaplan, Goodglass & Weintraub, 1983) and digit span from the WAIS-R (Wechsler, 1981).

4.2.2 MMSE (Folstein et al., 1975)

The MMSE is a standardized measure that provides a brief assessment of cognitive state. It is particularly useful for patients with PRAD as administration takes about ten minutes. Questions cover orientation, registration, attention and calculation, recall and language. Total score possible is 30, with scores below 20 typically found in patients with cognitive disturbance (Folstein et al., 1975). The range of scores for the patients tested on the MMSE was 4-22, with a mean of 13.1 (S.D. 5.2; see Appendix I).

4.2.3 CAPE (Pattie & Gilleard, 1979)

The CAPE provides a more detailed patient assessment. It comprises a measure of both cognitive performance and behavioural, with an additional performance task. The Cognitive Assessment Scale (CAS) is administered to the patient as a series of questions and tasks. The first section, information/orientation, is scored out of 12. The second section, mental ability, is scored out of 11. The third section is the Gibson Spiral Maze which provides a measure of concentration. The time taken to complete this task and the number of errors made form the basis of scoring, which is out of 12. CAS scores may range between 0 and 35. The Behaviour Rating Scale (BRS) comprises four sections and is completed by a relative or primary carer where appropriate. Each question can be scored 0, 1 or 2, where 0 is no problem, 1 is some problems, 2 is always a problem, depending on the behaviour. The four sections are physical disability, apathy, communication difficulties and social disturbance. Scores may range between 0 and 36. From the scores on the CAS and BRS, a dependency rating is derived. There are five levels of dependency. Level A is *independent elderly*, Level B is *low dependency,* C is *medium dependency*, D is *high dependency* and E *maximum dependency* (see Appendix I for participants' levels of dependency). Participants reported here ranged between B and E levels of dependency.

4.2.4 Auditory and visual lexical decision

Lexical decision is commonly used as the measure of efficacy in priming tasks. In these speed of lexical decision following a variety of primes is the focus. This method is used in healthy adults to collect data on a variety of issues including lexical access (Balota & Chumbley, 1984) and frequency effects (Balota & Chumbley, 1984, 1990; Monsell, et al., 1989). As a tool for probing impairments in neuropsychological patients lexical decision in a priming task is also useful (Blumstein, Milberg & Shrier, 1982; Milberg & Blumstein, 1981). There has been some limited application of this technique in PRAD (see Chapter 2; Albert & Milberg, 1989; Chertkow et al., 1989; Ober & Shenaut, 1988).

Lexical decision is included here to assess the patients' ability with auditory and visual stimuli. This is to evaluate the evidence for poor output performance occurring through input difficulties. The results are not used to screen out potential participants. Rather they serve to fill out the picture of each participant. The pattern of preserved and impaired functioning across tasks is of particular interest in PRAD patients, especially as the deterioration becomes more marked.

Method

Subjects Seven PRAD participants, S1, S2, S3, S4, S5, S6, S7 completed both parts, with an eighth, S11, carrying out only the visual task (see Appendix I for participant details). Three female elderly controls, C1, C2, C3 also did both parts and one male elderly control, C4, did just the visual task (see Appendix II for participant details).

Materials Twelve pronounceable nonwords were created that differed only in initial letter from permissible English words. The real word neighbours of the nonwords comprise both regular and exceptional pronunciations. Eleven of the nonwords are monosyllabic and the twelfth has two syllables (see Appendix III). Twelve English words, ten monosyllabic, two with two syllables. Their frequencies range between 1 and 524. For words that are both nouns and verbs, the higher frequency rating, generally the noun, is given (See Appendix III). Imageability ratings for these words are between 5.01 and 6.37. For the visual task the stimuli are on individual 3.5 x 5.5 inch index cards, each item written in black ink in the centre of the card in letters approximately two centimetres high.

Procedure **1) Visual lexical decision.** Each card was presented individually to participants. They were asked to say "yes" if they thought the written item was a word or "no" if they thought it was not a real English word. There was no time constraint on the speed of item presentation. All responses were recorded manually and on audio tape.

2) Auditory lexical decision. The experimenter read out each item in turn. Again participants responded "yes" or "no". There was no limit on the time allowed for responding. These responses were also manually and audio tape recorded.

For all participants the visual task preceded the auditory.

Results and discussion

Table 4.1 shows the total number of correct responses each participant made on each part. The mean scores for the PRAD participants are 22.29 for the visual and 19.14 for the auditory, a difference that is just significant ($t(6) = 2.386, p < 0.05$). The mean correct for the control group is 22.75 visual presentation and 23 auditory, neither of which differ significantly from the PRAD group means. Performance with words and nonwords also do not differ between the groups.

Participant	S1	S2	S3	S4	S5	S6	S7	S11	C1	C2	C3	C4
VLDT words	12	12	12	12	12	12	12	12	12	12	12	12
nonwords	11	12	7	11	12	9	10	12	12	9	12	10
ALDT words	12	12	10	12	10	10	12	NA	12	12	12	NA
nonwords	12	12	4	10	4	8	5	NA	12	9	12	NA

Table 4.1. Items correct on visual (VLDT) and auditory (ALDT) lexical decision tasks.

The control group correctly identified a mean of 24 words and the PRAD group 23.14. With nonwords the control group mean correct was 22 and the PRAD group 18.29. There is, however, a significant difference in the number of words and nonwords responded to correctly by the PRAD group ($t(6) = 3.198, p < 0.01$). These results suggest that the PRAD groups' comprehension for real words is not impaired. In addition, two of the four control subjects also made errors in classifying nonwords as words.

Plausible nonwords, such as TADE take longer to reject in lexical decision than less plausible nonwords such as XCSW (Coltheart, Davelaar, Jonasson & Besner, 1977). Such plausible nonwords, containing legal letter strings of a language, are sometimes called pseudowords. In this task it was not necessary to measure speed of lexical decision but it was observed that the PRAD group did take longer to decide whether the pseudowords were real English words or not. In addition, they had difficulty rejecting these words, particularly when presented auditorily. However, two of the four age-matched controls also made errors in accepting pseudowords. As one participant commented "it could be a word and I just don't know it".

The finding that the PRAD group took longer to decide for pseudowords suggests that they used the same procedures as healthy adults to reach a decision. That the age-matched controls also accepted some of the pseudowords suggests that the PRAD errors did not arise from a problem specific to them.

4.2.5 Digit span (WAIS-R)

This task is part of the Verbal scale of the WAIS -R (1981). It comprises two components: digits forwards and digits backwards. Digits forwards requires participants to repeat strings of numbers read out by the examiner. Numbers are read out at a speed of one per second. Number strings range from three items to nine with two different trials of each. Successful repetition of both trials is scored 2. One trial completed is scored 1. Failure on both trials scores 0. Presentation discontinues after failure on both trials of any item. Digits backwards requires participants to repeat back strings of numbers in reverse order. This component is preceded by two practice trials of three numbers. The test itself starts with two numbers and continues up to eight. The maximum score possible for the whole test is 28, 14 for each part. The two components both provide measures of short term memory with digits backwards particularly examining active, working memory (Lezak, 1983). However, Lezak points out that span rather thantotal may be more informative in patient groups. In this study, patients ranged between 2 and 10 forwards and 0 and 5 backwards (see Appendix I for all participant's scores). Thus some participants had reduced spans whilst others were in the normal range for their age.

4.2.6 Synonymy triplets

This task is from the Philadelphia Comprehension Battery for Aphasia (Saffran et al., 1989). It provides a measure of detailed word meaning with participants required to select which two of three written words are closest in meaning. The task examines both nouns and verbs.

Method

Subjects PRAD participants S1, S, S3, S4, S5, S6, S7, S11 all took part. They were all female. In addition, the four elderly controls, C1, C2, C3, C4, 1 male and 3 females also took part (see Appendices I and II for participant details).

Materials Fifteen noun triplets and fifteen verb triplets on 30 separate sheets. Four of the noun triplets appeared inappropriate for use with UK English speakers and were excluded (see Appendix IV).

Procedure There are four pre-test items to introduce the task. The first sheet contains a triangle and two circles. Participants are asked to indicate which two look the same. Incorrect responses are corrected. The second pre-test sheet contains a star, a rectangle and a square. This time participants indicate which two items are most similar. The third sheet contains the words *man*, *chair* and *boy* and the fourth *to run*, *to jog* and *to sit*. The examiner reads out each word in turn starting at the top of the sheet. Participants are asked to think about the meaning of each word and then decide which two are most similar in meaning. There is no limit on how many times the words can be read out. Errors are again corrected on these two practice sheets. Following this are the test triplets, presented one sheet at a time. The two words indicated by the participant are recorded but with no feedback on their correctness.

Results and Discussion

Table 4.2 shows the total numbers of nouns and verbs correct. Clearly the control participants performed better on this task than the PRAD participants. The PRAD group correctly identified 84% of the nouns and 82% of the verbs, whilst the controls achieved 97.7% and 100% respectively. The difference in percentage correct for the PRAD and control groups is significant (Mann-Whitney U = 0, $p < 0.01$). The noun scores of the PRAD group were scaled up to enable comparison with the verbs but there was no significant difference between them (nouns mean (out of 15) = 11.07, verb mean = 10.75; $t(7) = 0.43, p > 0.6$).

Participant	S1	S2	S3	S4	S5	S6	S7	S11	C1	C2	C3	C4
nouns /11	9	9	9	8	7	8	5	10	11	10	11	11
verbs /15	9	15	9	12	10	12	6	13	15	15	15	15
% correct	69	92	69	77	65	77	42	88	100	96	100	100

Table 4.2. Total number of nouns and verbs correct on synonymy triplets task and overall percentage.

The performance of the PRAD group is clearly impaired relative to the controls. The difficulties of the PRAD group do not differ across nouns and verbs. There are several possible explanations for this. One is that they have a problem accessing the specific word meanings. Another is that they have difficulty keeping the three meanings active concurrently. It is possible that the difficulties arise to specific items, perhaps those which are lower frequency or less familiar. As the materials were devised for use with a different population, these factors may not have been considered in the design. Overall, the PRAD group performed above chance level but with signs that the requirements of the task were difficult for them to meet.

4.2.7 Boston Naming Test

This task is widely used with neuropsychological populations. It is a series of 60 line drawings of concrete nouns, ordered in increasing difficulty.

Method

Subjects Eight PRAD participants S1, S2, S3, S4, S5, S6, S7 and S11 took part. They were all female (see Appendix I for participant details). The four elderly controls, C1, C2, C3, and C4, 1 male and 3 females also took part (see Appendix II).

Materials The BNT stimulus book and scoring booklet. Item number 19, *pretzel*, is not usually administered to UK populations.

Procedure Participants are shown each picture in turn and asked to name it. If they fail to do so a stimulus cue can be given. This is written on the score sheet and consists of a piece of information about the target item ("used for sitting" for *bench*, "an animal" for *camel*). If the item is still not named, then a phonemic cue can be given. This is also marked on the score sheet and consists of the initial sound of the target name ("ra" for *racquet*", "un" for *unicorn*). For healthy adults and older children it is recommended to start at item 30. Items before 30 are only given if participants fail to correctly name the first six items. The testing ceases when six consecutive items are failed. The number of spontaneously named items is scored. The number of cues are also recorded, plus the number of items named correctly following each cue type. However, only items named correctly after the stimulus cue are included in the total score, which is out of 59.

Results and Discussion

The total scores (calculated as explained above) are given in Table 4.3. Also included are the number of items correct after a phonemic cue, the number of the first item failed and the number of the highest item spontaneously named. Overall, the PRAD group performance is clearly worse than that of the elderly controls (mean PRAD total = 24.25, mean control total = 54.25; Mann-Whitney U = 0, $p < 0.01$). One explanation for this poor performance could be that they failed to recognise the items. However, this does not appear to be so in all cases as cueing with the initial phoneme led to production of the target names in an additional 59 (12.5%) responses. Also, where the target name was not provided there were many occasions when the stimulus cue was rendered unnecessary by the participant spontaneously offering equivalent information (S2 "is it a mountain?" for item 23 *volcano*; BNT stimulus cue "a kind of mountain"; S3 "net to sleep in" for item 39 *hammock*; BNT stimulus cue "you lie on it'; S4 "you pick things up with it" for item 54 *tongs*, BNT stimulus cue "a utensil").

	Total	No. correct	First failed	Highest named
S1	18	12	9	40
S2	24	14	5	40
S3	33	2	10	58
S4	20	12	5	42
S5	18	0	5	35
S6	16	8	11	25
S7	24	4	5	58
S11	41	7	29	57
C1	57	0	34	60
C2	58	0	59	60
C3	46	0	23	60
C4	56	0	56	57

Table 4.3 Totals on the Boston Naming test, number of items correct following a phonemic cue, the first item failed and the highest item spontaneously named.

Key: Total = total correct (maximum 59); No. correct = number of items correct following phonemic cue; First failed = number of first item failed; Highest named = number of latest item spontaneously named (highest 60).

This spontaneous information and the number of items named after phonemic cueing, which are not included in the total scored, suggests that just looking at the totals is of limited usefulness. This may provide a figure for comparison with other groups but it does not help in understanding the cause of poor performance. For instance, the PRAD group totals (range 16 - 41) correspond in the norms to the performance of young children. However, looking at the highest item spontaneously named reveals that some of the hardest items were named without difficulty. In addition, the scoring criteria do not allow for responses that describe the picture or something in it (S11 "eruption of some sort" for item 23 *volcano*; S6 "dog" for item 44 *muzzle*). This suggests that it may be more useful with PRAD participants to examine the whole response rather than just whether the target name is given (for instance Hodges et al., 1991, give a detailed analysis of PRAD participants responses on the BNT).

One final point is that the item first failed by four of the eight PRAD participants was number 5, whistle. This suggests that there may be a problem with the picture. As discussed above(Chapter 2, section 2.2.3) the naming performance of PRAD patients, at least in the more severe stages of the illness, is influenced by perceptual difficulties (Hodges et al., 1991; Kirshner et al., 1984). As such, the BNT may not be particularly useful for use with this population.

Summary

The main purpose of the background tests was to give a picture of the PRAD participants. This is particularly important for making comparison with other studies, especially where the participants may be at different stages of the deterioration process. It must be stressed again, however, that these data were only collected for participants taking part in experiments 3, 4, 5, and 7.

Chapter 5

Semantic-to-lexical processes: Experiments 1 and 2

The experiments in this chapter employ standard techniques for investigating speech production and semantic processing. Naming is commonly used with both normal and clinical populations. It is often coupled with a word-picture matching task for the target items. Taken together these tasks provide a measure of the status of target concepts in semantic storage and the relationship between targets and their labels. The tip-of-the-tongue (TOT) technique also provides a measure of the processes involved in lexical retrieval and the relationship between semantic information about a concept and its label.

5.1 Experiment 1: Naming and Comprehension

5.1.1 Introduction

In this first experiment I used a standard task combination to gather preliminary data regarding the speech production problem in PRAD. Subjects were asked to name spontaneously pictured items, followed by an assessment of their comprehension for the named items using a word-picture matching task. The naming task, requiring recognition of the item, location of the matching label from among many thousands, retrieval of the corresponding word form and generation of this is the more demanding task. There are more components involved in which problems can arise. The comprehension task is much easier. Recognition is promoted by having the two inputs of auditory presentation of the target and visual stimuli and by the limitation of choices in response to the stimuli (only four pictures are presented). In addition the task has both between- and within-category elements Of these between-category choosing is easier, as identification of an item's category is sufficient for selection when all other items are from different semantic categories. Within-category matching requires a more detailed match to select the correct target from among category co-ordinates. This element thus probes the depth of knowledge available about target items.

Additional information is provided by analysis of the non-target responses. These responses are distinct from "don't knows" and non responding. Non-target responses include alternative names for the pictured item, naming parts of the target item or other items in the picture and descriptive responses rather than single words. The nature of the errors indicate the loci of breakdowns in processing. For instance semantic errors in naming might suggest a problem at the recognition stage or in activating the label for a recognised concept rather than a problem with phonological word-form retrieval. Similarly, the selection of phonological distractors in between-category picture-word matching implies a problem with auditory input processes.

5.1.2 Method

Subjects. Participants S1, S2, S3, S6, S8, S9, S10, S12, S13, S14, S17, S22, eight females and four males took part (see Appendix I). Three of these were living in a psychiatric hospital, six attending day care at the same hospital and three living in residential homes in the community. The mean age at testing was 81:7 years, with a range of 70:11 to 88:4.

The naming task was also administered to two healthy elderly adults, 1 female aged 80:9 (C2) and 1 male aged 76:11 (C4; see Appendix II). These two controls were added to obtain some idea of healthy performance on this task as the drawings were not originally intended for naming. Their responses were rated using the above criteria and were not subject to any further analysis.

Materials. All items were taken from the Lexical Comprehension task from the Philadelphia Comprehension Battery for Aphasia (Saffran et al., 1989). The Lexical comprehension task is designed to assess lexical-semantic knowledge and does this by presenting the subject with a label (either verbal or written) which then has to be matched with one of four pictures on a sheet. There are two sets of words and pictures, the first is within-category items where the subject has to choose between four items from the same semantic category (semantic distractors). The second set uses the same target items but placed with semantically unrelated others. Here phonological and perceptual factors are sampled by either having one of the other items look similar or sound similar to the target. Saffran et al. (1989) suggest that relatively poor performance on the within category part of the task indicates problems accessing lexical-semantic information. If a subject performs poorly on both parts of the task then a more severe lexical-semantic disturbance is indicated. The perceptual and phonological elements were incorporated in the test to examine agnosic and phonological processing problems respectively.

In its original form there were 16 items in the within-category condition and 28 in the between-category one. For use with British subjects, 4 items from the between-category section were dropped because their distractor value was based on American pronunciations or names. This left 24 items in the between-categories condition, 16 with perceptual distractors and 8 with phonological. These 24 target items were selected for the naming task.

Procedure. In the naming task subjects were shown each picture in turn and asked to name the item. There was no time constraint on how long subjects had to answer. The comprehension task is preceded by two practice sheets to ensure that the subjects understand the requirements. All subjects completed the within-category part of the task first, with subjects being tested individually. Each sheet was presented in turn and the target item named by the interviewer. The subject was required to point to the target item. This was followed by the 24-question between-category section. Subjects performed the naming task before the comprehension task.

5.1.3 Results

Naming. A scoring system for the naming task was developed based on that of Hodges et al. (1991). Four additional categories were added to cover the full range of responses made (see below). All parts of the responses were considered in arriving at a rating. Each set of responses was rated independently by three raters. Discrepancies were discussed and agreement reached regarding classification.

Scoring criteria for naming responses:

1. Target or synonym (e.g. 'cabinet' for chest-of-drawers)
2. Correct circumlocution - sentence or phrase containing target.
3. Tip-of-the tongue (TOT) resolved with either the target or a synonym. The participant indicates that they know the name of the item but can not produce it straight away. After some time the target name is produced.
4. TOT unresolved. The participant indicates that they know the name of the item but they fail to produce it. The participant may produce related words or the initial sound of the target word.
5. Visual: responses visually similar to the target *and* from a different semantic category ('sweet' for strawberry; 'sole' for chop). Also includes whole-part responses where subjects name either a part of the target item (fence for crown; plates for money) or something incidentally present in the picture (' hair' for crown; ' collar', 'shirt' for tie).
6. Ambiguous visual/semantic category: responses from the same semantic category as the target *and* visually similar such that the error could be either perceptually or semantically based ('stool' for table; 'bullock' for goat; 'saxophone' for trombone).
7. Semantic-within-category: responses from the same semantic category as the target but clearly *not* visually similar ('lobster' for octopus).
8. Semantic-superordinate: responses denoting the general class or category to which objects belong ('animal' for goat; 'bird' for peacock).
9. Semantic associative: responses showing an obvious semantic association with the target item including statements of action or function ('something to eat' for steak),

physical attributes ('something that crawls' for crab), contextual associates ('in the kitchen' for steak), and specific subordinate or proper nouns examples of the target ('Rolls Royce' for car).

10. Semantic circumlocutory: multiword responses showing accurate identification of the target by physical attribute, function or action but not giving the name. Where the distinction between 9. and 10. is unclear, apply the following criteria: does the response describe a specific item? If so, score as 10.

11. Phonemic: mispronunciations or distortions of the target name sharing at least one syllable.

12. Perseverations: reutterances of a previous response (correct or incorrect) used to name one of the previous five pictures.

13. Unrelated: no clear relationship between the target and response can be deduced ('airy one' for strawberry; 'making a W. C.' for road).

14. Nonresponse: includes "don't know" and no response.

In addition to the above classification of responses, pairs of target words and substitutions were included in a separate rating task (Experiment 9, chapter 8). In this, the target-substitute pairs were rated for semantic relatedness by 14 independent raters. Raters assigned word pairs a value between zero and four using the following criteria: (1) no link: the meanings of the words are completely unrelated; (2) far-fetched link: the meanings of the words are related in some way; (3) weak link: the meanings of the words are slightly related in some way; (4) strong link: the meanings of the words are fairly closely related in some way; (0) where the meaning of one or both of the words is unknown, after Jones (1989; Jones & Langford, 1987). A mean rating of 1.5 or more was taken as indicating that the words are semantically related in some way (see Appendix V for mean ratings).

One of the two control subjects scored 23 correct and 1 ambiguous visual/semantic and the other scored 21 correct with 1 ambiguous visual/semantic responses, 1 semantic co-ordinate and 1 unresolved TOT respectively. The highest number of correct items by a PRAD participant was 22 and the lowest 4. Of the total 288 items there were 172 (60%)

containing the correct target (response categories 1, 2, and 3 - see Figure 5.1.). Eighteen of the 115 items scored incorrect were don't knows. Of the remaining responses 34 had some visual relationship with the target and 38 some semantic relationship (both including ambiguous visual/semantic responses), 5 were perseverative and 23 were unrelated.

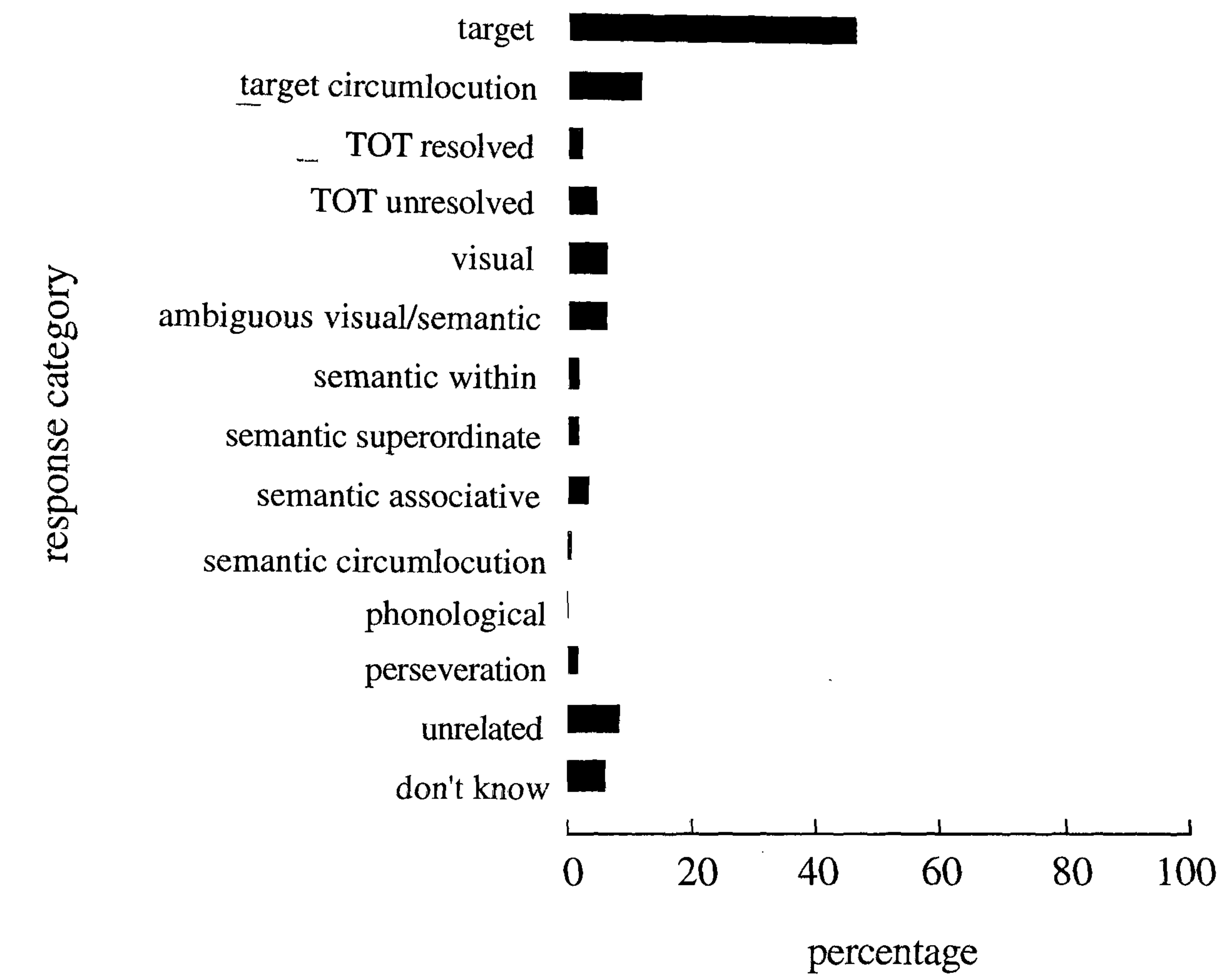


Figure 5.1. Distribution of naming responses across all response categories for PRAD subjects.

The classification of responses was supported by the semantic ratings of the target-substitution pairs to be discussed in Experiment 9. Sometimes more than one word was produced in a response and the total number of target-substitute pairs was 76. These pairs were from three groups of responses - categories 2-4 inclusive (TOTs and target circumlocutions), categories 6-10 inclusive (some semantic relationship) and category 5 (visual errors). Of these three groups, the pairs classified from categories 6-10, received the highest semantic ratings (mean 3.32). The ratings for responses from categories 2-4 were not much lower with a mean of 3.13. However, the responses judged to be visual errors received much lower ratings of semantic relatedness (mean 1.54).

Comparisons of the frequency, imageability and syntactic category were also made between the target words and substitutions produced in the visual and semantic errors , the TOT states and circumlocutory responses. Perseverative and unrelated responses were not included. Frequency ratings for both members of 59 of these pairs were obtained from Francis and Kuçera (1982) and there was no significant difference between them (mean target frequency 48.39, mean substitute frequency 40.18; $t(58) = 0.55$, $p > 0.5$). Imageability ratings for 30 target-substitute pairs were available from the Oxford Psycholinguistic Database (Quinlan, 1992) which is a composite value arrived at by blending ratings from the Paivio, Yuille and Madigan (1968), Toglia and Battig (1970) and Gilhooly-Logie (1980) imageability norms. As with frequency there was no significant difference in imageability (mean target imageability 6.01, mean substitute imageability 5.94; $t(20) = 0.65$, $p > 0.5$). Analysis of frequency and imageability was also carried out separately on the three largest groups of substitutions, the semantic, the visual and the ambiguous visual/semantic. Among these comparisons the only significant difference found was that targets of visual errors were more imageable than the erroneous responses (target mean 6.10, visual error mean 5.59; $t(7) = 2.26$, $p < 0.05$). All of the target words and all of the substitute words were nouns.

Comprehension. Subjects are scored for how many items they correctly identify and where mistakes are made on the second section, the errors are scored for being phonologically related, perceptually related or unrelated to the target. Performance on the naming and two comprehension tasks was significantly different ($F(2,22) = 33.85$, $p < 0.0005$) with the number of targets named lower than the number of items comprehended on both between and within category tasks (both at $p < 0.0005$). There was no significant difference in performance on the two elements of the comprehension task (within-category (scaled-up) mean = 19.75 and between-category mean = 21). On both parts of the task over 80% of responses were correct (see Figure 5.2). Performance on the 16 items occurring in both the within and between category parts was not independent with items responded to the same way on each ($t(15) = 2.695$, $p < 0.05$). Comparison across items revealed that the probability of naming an item that was also comprehended was greater than the probability of naming alone (within-category: $t(15) = 3.460$, $p < 0.005$; between-category: $t(23) = 3.175$, $p < 0.005$).

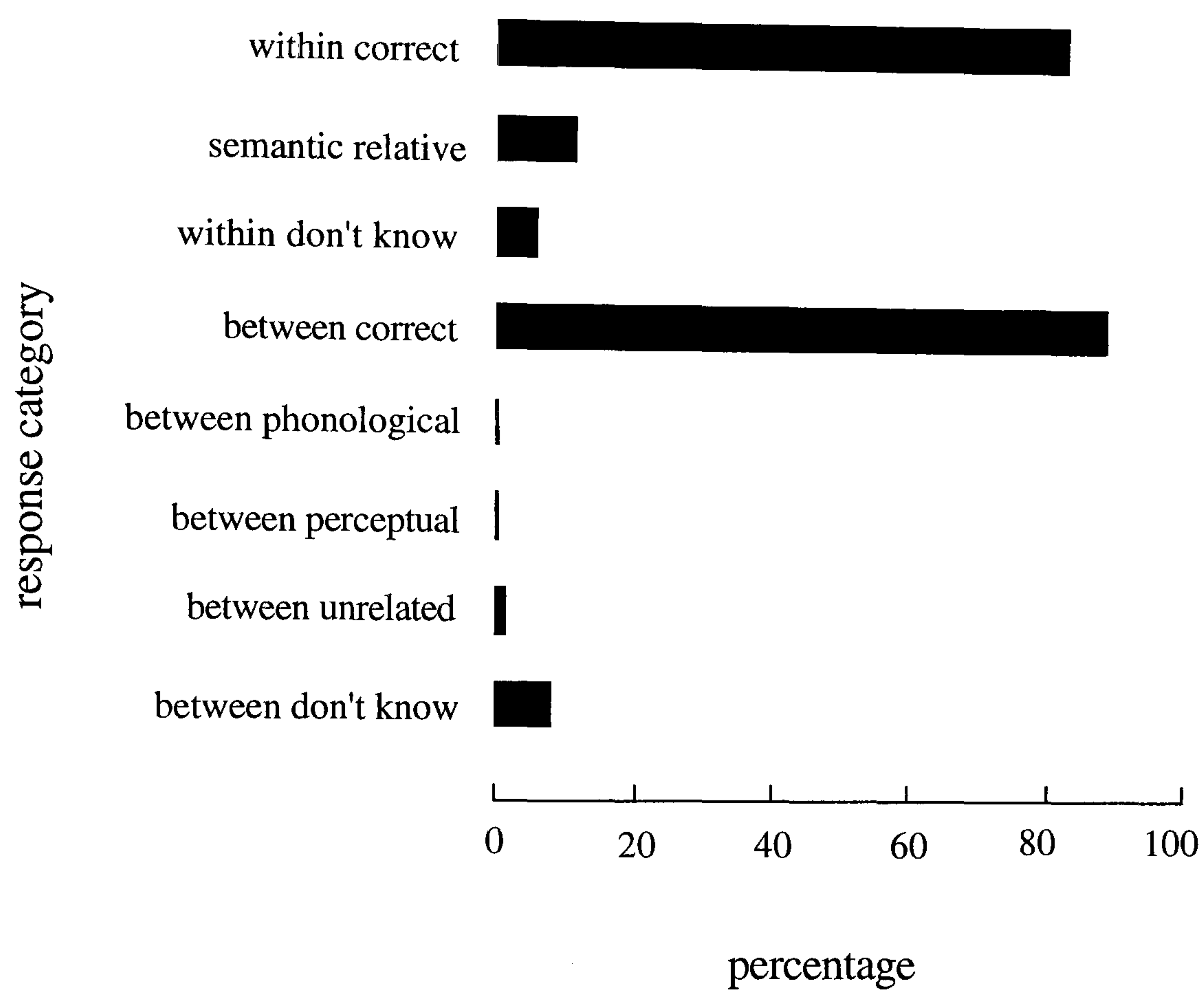


Figure 5.2. Distribution of responses on between-category comprehension and within-category comprehension.

On the within-category task 158 out of the 192 items were correct. Twice as many of the non-target responses were semantic distractors than were "don't knows" (see Figure 5.2). On the between-category part of the comprehension task 250 of the total 288 items were correct. The other 38 responses were either a phonological distractor, perceptual distractor, unrelated or don't know (see Figure 5.2). When subjects did not make the correct response they were most likely to make no response or say that they didn't know the answer (60% of non-target responses), rather than be distracted by a phonological or perceptual relative of the target.

5.1.5 Discussion

As expected the PRAD subjects performed better on the comprehension task than on the naming task. On the naming component a large part of the non-target responses were either unrelated or don't knows. Errors related to the target were distributed between visual and semantic with similar amounts of each. The increased number of superordinate semantic category responses reported in other studies (Flicker et al., 1987; Hodges et al, 1991; Martin & Fedio, 1983) was not found. Semantically related errors were as likely to be category co-ordinates of the target or even more likely to have some associative relationship with the target, such as its function. Targets and erroneous responses were all drawn from the same syntactic category and there was no frequency effect in substitutions.

In the comprehension task, the restricted choice and dual visual/auditory input apparently provided sufficient facilitation for the majority of items to be correctly identified. That there were so few perceptual errors on the between-category picture-word matching suggests there was no great problem with perceptual processing. It may be that the drawings were adequate within the constraints of the word-picture matching task but were inadequate to meet the demands of the naming task, where the targets of visual errors were more imageable than their substitutes. The low level of phonological errors suggests there were few problems with input phonological processes.

The finding that there was no difference in performance on the within- and between-category parts of the comprehension task suggests that the naming problem does not result from a loss of semantic knowledge for the concepts. The words for each item were understood, suggesting at least that input lexical procedures are intact. Indeed, only two phonological distractors were selected which suggests that there was no difficulty with input phonological processes. If input and output use different representations, this pattern of findings across naming and comprehension could be attributed to impaired output representations. However, if output representations were being lost or damaged, lower frequency items should be most vulnerable, being substituted for with higher frequency items as frequency is thought to be located post-lemma retrieval (Harley, in press;

Jeschniak & Levelt, 1994; Nickels, in press). This was not the case. The most plausible account is of shared representations for input and output, that is one, amodal lexicon, with problems in the output links between semantic and lexical representations.

5.2 Experiment 2: TOT 1

5.2.1 Introduction

The tip-of-the-tongue (TOT) experience has mainly been studied in young adults (see, for example, R. Brown & McNeill, 1966; Jones, 1989; Jones & Langford, 1987; Kohn et al. 1987; Perfect & Hanley, 1992). It is thought to be universal and occur on average once a week. R. Brown and McNeill (1966) induced TOTs experimentally by presenting subjects with definitions of rare words. They classified the words produced in a TOT state as either phonological or semantic relatives of the target and found that 70% were of the phonological type. In addition to the production of related words, young adults are often able to provide the number of syllables (Lovelace, 1987) and the initial letter or phoneme of the target word (Brown & McNeill, 1966; Koriat & Lieblich, 1974; Rubin, 1975; Yarmey, 1973). Sometimes the syllabic stress (Rubin, 1975), the last letter, and the position of additional letters are also available (Brown & McNeill, 1966; Koriat & Lieblich, 1974). (See A. S. Brown, 1991, for a review.)

The study of TOTs sheds valuable light on the processes of word selection and retrieval, both parts of the lexicalization process. In the experimental method of inducing TOTs, the definition can be seen as providing the semantic specification with which the lemma is selected in two-stage models of lexicalization. One plausible explanation of TOTs on the two-stage model is that the lemma stage is successful, but that lexical to phonological retrieval fails, or is only partly successful. This leads to the subjective feeling of knowing the word, accounts for the higher incidence of phonological neighbours relative to semantic neighbours of the target produced by subjects, and explains the partial availability of phonological and structural information.

An alternative account of TOTS is that based on an investigation of TOTs in older adults by Burke et al. (1991). Their *transmission deficit* hypothesis states that target items do not receive sufficient activation to be retrieved, with word frequency, recency and ageing contributing to this occurring. Burke et al. (1991) based this on differences in TOTs between older and younger speakers. TOTs occur more frequently with age, and elderly subjects are more likely than young or mid-age adults to recall little or no phonological information about the target word (Burke, Worthley & Martin, 1988; Burke et al. 1991; Cohen & Faulkner, 1986; Maylor, 1990). They are less likely than younger adults to produce alternative words (Burke et al., 1991; Cohen & Faulkner, 1986) and are more likely to give up pursuing the target and think about something else (Burke et al., 1991). Older adults are less likely to provide the sort of phonological and structural information that is commonly supplied by younger adults such as number of syllables and the last letter. It is also possible, however, to account for these findings with the two-stage model of lexicalization. The different characteristics of older adults' TOTs suggest that with increasing age their occurrence is not just a straight forward failure at the lexeme stage. This breakdown is probably combined with difficulties elsewhere in the system, or with increasing age it happens earlier in the process, possibly between the semantic and lexical levels (lemma access).

TOTs can provide valuable information about the accessing of labels from verbal descriptions. Miller (1979) argued that the disinhibition of plausible alternatives, proposed by Warrington and Weiskrantz (1970) to explain word retrieval difficulties of amnesics, was also a possible explanation for the decline of retrieval abilities in dementia. This holds that retrieval and production of the target word depends, in part, on the successful inhibition of rivals (i.e. related words), and that a gradual increase in disinhibition could account for retrieval difficulties. Miller's (1979) disinhibition explanation has similarities with Jones and Langford's (1987) blocking hypothesis of TOTs. With this account TOTs are attributed to the blocking of targets by competitors, although they do not discuss failure to inhibit as a causal mechanism. The inhibition hypothesis finds further support from selective attention tasks that suggest that decreased efficiency of inhibitory mechanisms follows with increasing age (Hasher, Stoltzfus, Zacks, & Rypma, 1991). This disinhibition explanation also fits well into connectionist two-stage accounts of lexicalization where within-level inhibition is an important processing mechanism (Harley & MacAndrew, 1992; Stemberger, 1985).

I used the verbal definition design of R. Brown and McNeill (1966) to induce TOT states in individuals with PRAD and age-matched controls. As my main concern is speech production, I analysed spoken responses. The majority of studies that use TOT to investigate retrieval processes have used a written response format. Such methodology has produced TOT rates of 13% (R. Brown & McNeill, 1966), 20% (Jones & Langford, 1987), and 23% (Perfect & Hanley, 1992) in young adults. These figures reflect so-called *subjective TOT experiences* (Jones & Langford, 1987), which are whenever subjects indicate that they are in a TOT state. Contained within these are a subset, named *objective TOTs*, in which subjects can provide partial information about the target and do not give any incorrect information. The proportion of responses that were objective TOTs in previous experiments were only 3.5% (Jones & Langford, 1987) and 4.5% (Perfect & Hanley, 1993). The most likely explanation for the high proportion of subjective TOTs is that when written responses are required subjects record TOT states when they just feel that they know the word, and do not necessarily reflect lexical access. Thus subjective TOTs may be another name for so-called feeling-of-knowing responses in other studies (Maylor, 1990; Yaniv & Meyer, 1987). By recording verbal responses I hope to more easily distinguish true TOTs from subjects feeling that they know, or should know, a word. The target words are of higher frequency than those of R. Brown and McNeill, as naming studies have shown poor performance by dementing patients on low frequency items (Kirshner et al., 1984; Skelton-Robinson & S. Jones, 1984).

As older aged subjects, the PRAD participants should show a high incidence of TOT states. They should also provide little or no phonological information about the targets, and produce few related words. Those which are should be semantically rather than phonologically related to the target. TOTs should also provide information on whether there is a difficulty in accessing semantic knowledge, or of a loss of that information (Nebes, 1989). If semantic knowledge has been lost, then in TOT states PRAD subjects should have preferentially preserved knowledge of superordinate information relative to subordinate, should show a disproportionate loss of information about low frequency items, and, in as much as loss of facilitation by priming reflects the inability to activate partial information, they should be generally poor at producing related competitors to the target (Chertkow & Bub, 1990a,b; Hodges et al., 1991, 1992; Warrington & Shallice, 1984).

5.2.2 Method

Subjects. Participants S1 - S6, S9, S10, S15, S16, S17, S18 all took part (Appendix I). They are ten females and two males aged between 75:8 and 88:3 years (mean age 81:11, standard deviation 3.74). Their mean years of formal education was 10.08 (range 9 to 12 years, standard deviation 1.44).

The control group comprised 12 elderly volunteers - C1, C2, C5, C6, C7, C8, C9, C10, C11, C12, C13 and C14 - (see Appendix II). They were nine females and three males who were all living unsupported in their own homes in the community. Their ages ranged between 72:0 and 84:0 with a mean age of 78 (standard deviation 3.93). Their years of formal education ranged between 9 and 15, with a mean of 10.16 years (standard deviation 1.89).

Materials. The twenty four words used are listed in Appendix VI. According to Francis and Kuçera (1982), twelve were high frequency words, each occurring more than 25 times per million (mean 49), and twelve low frequency, occurring less than 10 times per million (mean 3.5).

Procedure. Both groups were given the definitions to read, revealed one at a time. If a participant was unable or unwilling to do this the experimenter read them out. They were usually read at least twice, in a random order. Subjects' verbal responses were recorded manually. All the control subjects completed the task in one session of approximately ten minutes. Some of the PRAD participants found the task very demanding and completed the task over two sessions.

If the subject produced a word in answer to the definition, it was recorded and the next definition was given. Sometimes subjects immediately said that they did not know the answer and on some trials subjects offered irrelevant information as a response to the definition. A subject was deemed to be in a TOT state only if they indicated that they knew the word but were unable to retrieve it, and if they carried out an active search in an attempt to locate the target word. These were often marked by phrases such as "it's on my tongue" and "I can't get my tongue round it". They were then asked to give any information they could about the target for which they were searching. All subjects in a TOT state that was unresolved within three minutes were given the opportunity to have a second attempt if they wished following presentation of all the definitions. When a subject failed to produce a response or if they were in an unresolved TOT state, the target word was supplied. When given the target word, subjects either spontaneously confirmed or were asked to confirm if the word supplied was the word that matched the definition and for those subjects experiencing TOT states, if this was the word for which they were searching.

The semantic relationship between target and responses was judged by fourteen independent raters (see Experiment 9, chapter 8). In addition a control pool of 40 word pairs was generated by randomly pairing target words with responses from this and Experiments 1, 4 and 5.

5.2.3 Results

Responses were classified into five categories. First, a "don't know" or no response at all. Second, the correct production of the target word. Third, a TOT state, which might eventually be resolved (or not) to the satisfaction of the participant. In some TOT states participants produced words as an attempt at the target; we call these *relatives* of the target. The fourth category comprises words produced by subjects as what they considered to be the appropriate response to the definition. This group will be called *own-target words* to distinguish them from the target words of the experimenter. The fifth category we call *constructive search* items, where subjects either made guesses at the target or embarked on a constructive search for the target word: these responses are distinct from TOT states in that subjects knew that the words were not the ones that fit the definition, but at the same time they were not in a TOT state. TOT, own-target words and constructive search responses are termed non-target responses and only the "don't know" responses are considered incorrect and therefore not analysed further. I compare the relationship between target and non-target responses with regard to frequency, imageability (where there are enough items to enable a meaningful analysis), phonology, syntactic category, and semantic relationship, as these factors are known to be important in word substitutions in normal speakers (Harley & MacAndrew, in press). The imageability of items was compared using ratings taken from the Oxford Psycholinguistic Database (Quinlan, 1992).

Response type	Control group	PRAD group
Correct target word	230 (80%)	129 (46%)
Don't know	1 (0.5%)	42 (14%)
Resolved TOT	9 (3%)	20 (7%)
Unresolved TOT	7 (2.5%)	16 (5%)
Own-target word	17 (6%)	41 (14%)
Constructive search	24 (8%)	40 (14%)

Table 5.1. Comparison of responses made by control and PRAD group, by absolute number and percentage.

Overall comparison of PRAD and control group. Over the 288 definitions, the control group made 230 (80%) correct responses to the target and the dementia group 129 (46%), with means of 19.17 (range 16-22) for control subjects and 10.75 (range 4-19) for experimental subjects (see Table 5.1). This difference is significant ($t(22) = 6.84$, $p < 0.001$). The dementia group also made significantly more "don't know" responses or no response at all, with means of 0.08 for the control group and 3.50 for the dementia group ($t(22) = 4.01$, $p < 0.001$). Looking at all valid responses, that is, all trials upon which a response was attempted, the 36 TOTs of the dementia group comprised a significantly higher proportion than the 16 TOTs of the control group ($\chi 2$ (1, N = 53) = 12.35, $p < 0.001$). The PRAD group responses are more evenly distributed across the response categories. Hence, as predicted, the dementia group were poorer at lexical retrieval and made more TOTs.

TOT data. All of the control group TOTs were induced by low frequency items. There was a significant difference in the degree to which high and low frequency items induced TOT states in the PRAD group (t 22) =5.09; $p < 0.001$), with a mean number of TOTs of 2.33 for low frequency items and 0.583 for high frequency items. There was a significant difference in imageability between words that induced TOTs and those that did not ($t(15) = 2.81$, $p < 0.05$), with those targets that did being lower in imageability (mean = 5.60) than those that did not (mean = 5.99). It should be noted that there was no significant correlation between frequency and imageability in the target words ($r_p(14) = +0.42$). The PRAD group could not report any partial phonological information about the targets they had in mind.

TOT relatives. Relatives of the target words were produced in TOT states by both groups. This happened with 9 of the 16 control TOTs, producing 11 relatives, and in 18 of the 36 PRAD group TOTS, producing 33 relatives. Two of these were non-words (see Appendix VII). Table 5.2 shows the mean frequency of the targets and the words that came to mind in a TOT state. The mean was calculated using only the pairs where both members have a frequency rating of at least 1 per million.

The relatives produced by both groups while in a TOT state did not differ significantly in frequency from the targets (PRAD $t(22) = 0.41$, $p > 0.5$; control $t(6) = 0.91$, $p > 0.1$). All of the target and relative words were nouns. All of the control group targets and relatives, and 30 of the 31 word relatives produced by the dementia group, were semantically related on the basis of the judging task in Experiment 9. The semantically unrelated word, "ottoman", was judged to be a phonological relative of the target, *octopus*, according the criteria of Harley (1984) of shared initial letter and number of syllables. T-tests further confirmed that the TOT relatives were semantically related to the target compared with the random word pairs ratings in both the control ($t(49) = 18.2$, $p < 0.001$) and PRAD ($t(69) = 17.96$, $p < 0.001$) groups. There was no significant difference between the PRAD and control groups ($t(40) = 0.99$, $p > 0.3$).

PRAD group					
	mean frequency	mean imageability		mean frequency	mean imageability
target	11.09	*	TOT word	13.70	*
target	12.37	*	own-target	36.15	*
target	18.35	5.77	search	39.41	5.62
Control group					
	mean frequency	mean imageability		mean frequency	mean imageability
target	3.29	*	TOT word	9.00	*
target	12.82	*	own-target	7.27	*
target	12.44	5.56	search	5.61	5.49

Table 5.2 Mean frequency and imageability ratings for the target and non-target response words

Note*: Too few word pairs with imageability ratings.

The nature of the semantic relationship between target and relative was explored using the semantic category norms of Battig and Montague (1969). From these category names were considered as superordnates and category members as subordinates. In the PRAD group all but one relatives were category co-ordinates of the target, and the one instance of a superordinate category name (from Battig & Montague, 1969, "snake" for *octopus*) might also be best interpreted in this way, as both are members of the category animals. The semantically related words produced by the control group were all category co-ordinates of the targets.

Own-target words. Table 5.2 shows the mean frequencies for target and own-target words. There was no difference between the frequencies for either group (PRAD, $t(26) = 1.13$, $p > 0.1$; control, $t(10) = 0.78$, $p > 0.1$). All of the control group own target words were singular nouns. Of the 41 own-target words produced by the PRAD subjects 34 were nouns, 5 were noun phrases, 1 a proper noun and 1 an adjective. In addition, 5 of the nouns were pluralized, whereas the targets were all singular nouns.

Two of the PRAD own-target words had ratings below 1.5 (see Appendix VIII), while all of the control group ones were judged to have a semantic relationship. Both the control ($t(55) = 36.67$, $p < 0.001$) and PRAD ($t(79) = 14.06$, $p < 0.001$) own-targets were more semantically related to the targets than chance, but there was a significant difference between the two groups ($t(56) = 3.05$, $p < 0.005$), with the PRAD group less related.

The PRAD group did not produce any superordinate category labels as own target words although the noun phrases “enthusiastic worker” (for *botanist*), “greedy animal” (for *turkey*) and “big fish” (for *octopus*) could perhaps be interpreted as this. Among the control group own target words there was one category subordinate.

Constructive search words. These are words produced by subjects as they actively searched for the response to the definition, but were not so sure of the target word that they felt themselves to be in a TOT state. The PRAD group made constructive search responses 62 times over 40 trials and phrases, and the control group made 28 responses over 24 trials. The words produced by the PRAD group while actively searching for an answer to the definition were higher in frequency than the target words ($t(45) = 2.20, p < 0.05$); this difference was not found in the control group between targets and constructive search words ($t(17) = 0.78, p > 0.1$). There was no significant difference between the target and search words on imageability for either group (PRAD, $t(19) = 1.12, p > 0.1$; control, $t(8) = 0.29, p > 0.5$). The PRAD group search words were 58 nouns, 1 noun phrase, 1 adjective and 2 gerunds. All of the control group search words were nouns, with one pluralized.

Three of the 62 PRAD group search words were judged to be not semantically related to their targets, while all of the control ones had a semantic relationship (see Appendix IX). Both control ($t(66) = 37.78, p < 0.001$) and PRAD ($t(100) = 13.60, p < 0.001$) groups were semantically related, although again the PRAD group search items were less related than the controls ($t(88) = 4.16, p < 0.001$). The PRAD group produced two superordinate category terms.

5.2.5 Discussion

The most salient finding is that the PRAD group was poorer at lexical retrieval, giving fewer correct answers and having more TOT states in response to definitions than their age-matched controls. TOTs are more likely to occur on low frequency, low imageability targets. Items produced in TOT states by the PRAD group tend to be semantically related to the target, but not as closely as those produced by the controls. Relatives were largely category co-ordinates rather than super-ordinates. Words are syntactically related to the target, but again less so than the controls. Hence there is a gradation such that although words produced in TOT states were related to the target in both groups, the constraints are less effective in PRAD patients.

TOT states accounted for 5.5% of control group responses and 12% of the PRAD groups'. If objective TOTs are taken as the true equivalent of verbal TOTs in written-response studies, these findings can be compared to the 3.5% of Jones and Langford (1987) and

4.5% of Perfect and Hanley (1993) with young adults. Thus my results accord with the noted feature that older adults experience more TOT states than younger adults (Burke et al., 1988, 1991). When they felt they should know a word but were sure that it was not on the tip-of-the-tongue, constructive search responses were produced. This suggests that these responses are recorded as TOT states in many written-response tasks. This issue is explored in Experiment 8 (see Chapter 9). Thus, objective TOTs provide a more accurate record, in written-response tasks, of TOT experiences. By using spoken responses I have captured true TOT states and this has enabled the separation of responses into different categories. This supports the view of Kohn et al. (1987) that spoken responses more accurately reflect the naturally occurring TOT state.

The relatives produced by both groups while in a TOT state did not differ significantly in frequency from the target words. Similarly, the targets and relatives tended to be from the same syntactic categories, and were usually semantically related. Analysis of the own target words revealed similar characteristics. The lack of frequency effects in the TOT relatives and own target words and the large proportion of category co-ordinates among these do not support the suggestion that subordinate level, item-specific semantic knowledge is lost. These findings suggest either that it is temporarily inaccessible so that semantic competitors cannot be distinguished, or that semantic relatives with similar specifications are not successfully inhibited.

As noted above the constructive search responses strongly resemble feeling-of-knowing responses reported in other studies. Subjects actively search to find the correct answer, offering suggestions as they pursue the target. This process can be likened to the *generation-recognition*, or *extrinsic-cueing*, identified by Jones (1978). This route to retrieval is based on the generation of words related to the target using extrinsic knowledge. The words produced whilst making a constructive search by the PRAD group were significantly higher in frequency than the targets while the control group search words were not. This difference in frequency may be due to the PRAD subjects carrying out the generation process out loud. For instance, one participant when searching for the target *geography*, generated a list of school subjects. The control group constructive search responses were mostly one word followed by them apparently rethinking and then offering another. The occurrence of constructive search responses, combined with clear "don't know" responses, support the notion that monitoring of cognitive processes is retained not just in the early stages of PRAD (Bäckman & Lipinska, 1993), but also as the disease process becomes quite advanced.

Across all the response categories, most of the PRAD responses were syntactically and semantically related to the targets, but less so than the control groups'. Such semantic and syntactic similarity mirrors the pattern found in normal speech errors and reflects the operation of multiple constraints in word substitutions in normal spontaneous speech (Harley, 1984, 1988). This provides evidence that the process of spreading activation and most of the units from which activation originates must both be preserved. However, that the constraints operate less strongly than in the control group, as evinced by the weakened semantic and syntactic constraints, suggests that the links along which activation spreads are weakened. This accords with the simulations of Harley and MacAndrew (1992), who proposed that aphasic naming difficulties result from weakened connections between semantic and lexical units.

In older adults, fewer relatives and less phonological information about the target are produced. The PRAD group offered even less phonological relatives of the target. This supports the idea that with increasing age TOTs are attributable to a different failure in the lexicalization process than that which causes them in younger subjects. I proposed above that in younger subjects TOTs are attributable to a failure between the lexical and phonological levels following successful access of the lemma stage. The different response pattern in older adults suggests that the lemma stage is not completed successfully and this leads to TOT states, as the target lexical item receives insufficient activation to become output. The semantic specification activates related lemmas and sends activation down to their respective phonological forms. The target lemma does not receive sufficient activation, as opposed to the target *phonological* representation in younger adults. In this case the relatives will be semantically rather than phonologically related to the target. If this shift is accentuated in dementing subjects, or if the connections are further weakened, then even less phonological information will be retrieved. Low frequency, low imageability items are particularly susceptible to loss as their activation levels will be lower. This finding is further evidence that two stages are needed to account for lexicalization phenomena, and these results are consistent with the insufficient activation theory of origin.

5.3 Discussion of results from Experiments 1 and 2

The results of both studies focus exploration of language disorder in PRAD on the lemma stage of the lexicalization process. Positing a failure at the lemma stage has a variety of implications depending on exactly how the breakdown occurs. The results of both experiments primarily support the weakened semantic-to-lexical connections version of the insufficient activation hypothesis. However the greater number of own-target and "don't know" responses in the PRAD group suggests that loss of units might also occur, particularly in the severest patients. Further exploration of the knowledge available about items and the processes involved in both comprehension and production tasks is suggested. Chapters Six and Seven detail a series of experiments with the same target items in each. This is to explore more fully the knowledge available about a set of items, rather than relying on performance of individual tasks to draw conclusions about the state of their representations.

Chapter 6

Exploring competing hypotheses: Experiments 3, 4 and 5

I designed four tasks to investigate the hypotheses presented at the end of Chapter Three. To summarize, these are first that lexical items, the labels, are lost or damaged; second, that the within-level inhibitory links between competing items gradually become lost, leading to phonological blocking between competitors; third, that semantic units are lost; fourth the links between the semantic and lexical levels gradually become lost. To distinguish between these explanations I examine the status of semantic and lexical representations for the same target items across a variety of tasks. The use of the same targets is particularly important for exploring the issue of consistency in responding. This issue is explored in Chapter 8 where the performance of one group of PRAD participants across all four tasks is examined. The intention is to cover a range of different ways of accessing and manipulating stored representations. This is to establish whether item-specific information is lost, whether item names are lost or whether these two types of information are intact but the connections between them are failing.

The four tasks are described below. The results of three of them are contained in this chapter. The fourth task, producing definitions (Experiment 7) is reported in Chapter 7. This is to permit comparison with definitions of the same targets produced by young healthy adults (Experiment 6).

6.1 The tasks

1. **Category fluency with four categories.** Participants are required to generate as many items as possible in 90 seconds from each of four semantic categories. The four categories selected are *musical instruments, furniture*, *vehicles* and *clothing*. This task is to gain a measure of how items are arranged within semantic categories. Analysis is concentrated on the number of items generated in each category and what the actual items are.

2. **Naming of 24 items** using colour photographs. The items are selected from the four categories as follows: 6 high frequency prototypical items (HT); 6 low frequency prototypical items (LT); 5 high frequency atypical items (HA); 7 low frequency atypical items (LA).

The 24 items are:

HT	LT	HA	LA
dress	trousers	bath	turban
shirt	sofa	curtains	apron
chair	van	rocket	hammock
train	trumpet	cap	barge
car	violin	coach	tambourine
piano	wardrobe		castanet
			recorder

This task is included to sample directly the lexicalization process involved in producing a label for an item. Photographs rather than line drawings are used to provide good quality stimuli to minimise possible effects of difficulty with perceptual processing. The total number of items correct and types of errors made form the focus of the analysis. The errors should provide some indication of how much of the specific attributes of the item are used to retrieve the label.

3. **Comprehension task for the 24 items** using both within- and between-category choices, as in Experiment 1. This task is less demanding than the naming task and provides an opportunity, especially when an item is not named in the naming task, to investigate whether the item is apparently lost completely from the semantic system or whether it just could not be retrieved in response to the visual stimulus. Between-category picture-word matching investigates recognition of the category that an item is from. Successful within-category performance indicates that the item itself can be distinguished from other category members.

4. A **TOT** experiment using definitions of the 24 words, as in Experiment 2. This task, like the naming task, also investigates retrieval processes. The TOT task provides another measure of how the semantic specification is accessed and selection of the corresponding lexical item is made and again, the errors are a valuable source of information.

5. **Definitions** of the words by the participants. This task is to gain information about what features are generated and available to a subject when the target word is presented.

A small group of age-matched controls also perform each task to give some indication of the validity of the measures. Data for the two groups are presented in each individual experiment, but interpretation of differences between the two groups must be made cautiously, bearing in mind the size of the control group. The mean score of the controls on the MMSE (29.25; range 27-30) corresponds to that reported for age-matched controls in many other studies (Folstein et al., 1975 - 27.6; Money et al., 1992 - 28.9; Ripich et al. 1991 - 28.36).

6.2 Constraints on item selection - frequency and typicality.

The reputed influences of both target frequency and typicality require further explanation.

6.2.1 Frequency effects.

There was little effect of frequency on the substitutions observed in Experiments 1 and 2, in that generally they were of similar frequency to their targets. However, frequency is included as a variable again for two reasons. First, so that the fourth task, TOT 2, may act as a test of reliability of the findings from Experiment 2. Second, there was a frequency effect in the targets of TOTs in Experiment 2, in that more TOTs were made to low frequency items than high. Items are again selected from the Francis and Kuçera (1982) frequency norms, this time using occurrence more than 20 times per million as high and less than 20 as low.

A further reason for retaining frequency as a constraining variable arises from the wider issue of its relative influence in a variety of tasks. Frequency has been shown to effect both speed of lexical decision (e.g. Whaley, 1978) and picture naming (Oldfield & Wingfield, 1965). It also influences the likelihood that a word will be the target in a speech error (Harley & MacAndrew, 1994; Stemberger, 1984). However its influence may differ depending on the task (Balota & Chumbley, 1984) and may also be confounded by other variables, such as familiarity and age-of-acquisition (Carroll & White, 1973a; Gernsbacher, 1984; Morrison, Ellis & Quinlan, 1992). In addition, attempts to identify the locus of frequency effects are directly relevant to any interpretation of performance in PRAD based on current speech production models.

Confounded effects. Alongside frequency, familiarity influences lexical decision whereby more familiar words are responded to quicker than less familiar (Balota & Chumbley, 1990). Indeed, Gernsbacher (1984) proposed that the subjective measure of rated familiarity of a word operates independently of printed word frequency and could be substituted for frequency in tasks involving written word recognition (see also 6.2.2 below for other measures of familiarity). Familiarity has also been proposed as the most influential variable in picture naming (Funnell & Sheridan, 1992). In an initial experiment of naming and providing a definition, using pictures and familiarity ratings from Snodgrass and Vanderwort (1980), low frequency items were named worse than either medium or high frequency items by a patient with right temporal lobe damage. Performance on this set of items correlated with both familiarity and semantic catgeory but not written word frequency. In a second naming experiment, with frequency held constant, familiarity but not semantic category, specifically living or non-living, influenced performance (Funnell & Sheridan, 1992).

Brown and Watson (1987) investigated the plausibility of the substitution of subjective familiartity for objective frequency by attempting to isolate the influences on ratings of familiarity. They found age of acquisition (AOA) most influential, followed by spoken word frequency, then written word frequency. With regard to word naming latency they found familiarity did not have a significant influence, nor did spoken or written word frequency. The only significant variable they found was AOA, a finding also reported by Carroll and White (1973b). A similar finding was reported for object naming by Morrison et al. (1992). Whilst challenging the independence of familiarity as an influencing variable, these findings also challenge the status of frequency. Brown and Watson (1987) suggest that all of the variance attributed to frequency in these tasks may actually be accounted for by familiarity, which itself is most influenced by AOA.

Differential effects. The magnitude of frequency effects, such as quicker naming of more frequent items and faster decisions that the target is a word, has been found to vary across tasks. Balota and Chumbley (1984) reported a minimal influence of frequency on category verification, significantly more on pronunciation and a large effect on lexical decision. They argued that using the results of lexical decision tasks to support the effect of frequency is misleading. In addition the size of the frequency effect in lexical decision can be reduced to the lower level found in naming by controlling the frequency of orthographic neighbours of the target (Grainger, 1990). Words with at least one higher frequency neighbour produce longer lexical decision times, whilst this facilitates speed of naming.

Morrison et al. (1992) found no effect of frequency on semantic categorization but effects of prototypicality and semantic category. In contrast, Monsell, Doyle and Haggard (1989) reported an effect of frequency on semantic categorization as large as on lexical decision. In addition they found frequency effects on syntactic categorization and word naming (Monsell et al., 1989). In a response to Monsell et al. (1989), Balota and Chumbley (1990) point out that the former did not partial out other factors which have an influence on categorization such as typicality. This omission, they claim, could underlie the findings of a frequency effect at odds with other reports of no effect on categorization.

Locus of effects. Using a delayed response design to explore the frequency effect on pronunciation Balota and Chumbley (1985) claimed it arises post-lexical access and may be attributable to the articulatory fluency of the target. With a similar task Savage, Bradley and Forster (1990) showed that the effect of articulatory fluency in pronunciation is minor and that the reported frequency effect is indeed attributable to the frequency of occurrence of the stimuli. A similar lack of articulatory effect in word naming was found by Brown and Watson (1994). Similarly, the notion that the locus of the frequency effect is post-lexical access was challenged by Monsell et al (1989). They claim it arises at the stage of lexical identification and that its influence on all tasks involving this step should be similar.

In an exploration of the locus of the frequency effect in picture naming Jeschniak and Levelt (1994) also discounted the influence of articulation. In addition they concluded that it is not attributable to the process of object recognition but arises in lexicalization. Using high and low frequency homophones they concluded that the frequency effect does exist and arises at the level of the phonological word form (Jeschniak & Levelt, 1994). Frequency was also located at the phonological level by Nickels (in press) on the basis of aphasic naming errors. In an analysis of the same data, Harley (in press) also locates frequency post-lemma retrieval but sites it in the links between lexical and phonological representations, rather than in the phonological representations themselves.

The accounts of Jeschniak and Levelt (1994), Nickels (in press) and Harley (in press) are all based on two-stage models of lexicalization. Their interpretations highlight how the differential and confounding effects can be explained in a model where frequency is located post-lemma retrieval. Semantic tasks, such as categorization and category fluency should therefore not be greatly influenced by frequency. We might also conclude that the frequency located post-lemma access is spoken word frequency, which has been shown to be independent of written word frequency (Brown & Watson, 1987). This then leaves the question of where written word frequency resides. As the available norms are based on words to be read, it seems reasonable to propose that it is located in the orthographic input representations. In models favouring shared orthographic representations for reading and writing, written word frequency would be located in either the orthographic representations or in the input links. This would account for the frequency effects in lexical decision which have no spoken output and therefore should not be influenced by spoken frequency.

Predictions. There is no apparent phonological problem with word forms in PRAD and phonological errors do not occur more frequently. As frequency lies post-lemma access, we should not expect there to be particular effects of frequency in output. As the difficulty in PRAD arises somewhere in the lemma stage any frequency effects could arise from at least two other sources. First, there could be an influence of frequency at the input stage, such as the written word frequency of a stimulus item. Second, frequency could be confounded with some other variable that influences semantic, semantic to lexical or lexical processing. I expect similar errors to those made in Experiments One and Two to occur in the second naming and TOT tasks: that is semantic errors should not be influenced by frequency. In the verbal fluency task I expect the role of frequency to be minor compared to that of typicality.

6.2.2 Typicality

Besides frequency, item selection is also controlled by typicality. Categories and items are selected from the category norms of Battig and Montague (1969) and Hampton and Gardiner (1983). In Battig and Montague's norms items are ordered in terms of *frequency* of production of an item as a member of a given category. Thus the most frequently given item is ranked first and so on. Where items were given by less than ten people, rather than a ranking, their number of occurrences is recorded. In addition, the number of times an item was produced as the *first item* in a category is also given.

The norms of Hampton and Gardiner were produced partly to address the issue of differences between British and U.S. English usage. They selected 12 categories from Battig and Montague's 56 and their norms include ratings for *associative frequency*, a measure of the probability of producting an item in response to a given word (in this case a category name), for *typicality*, how representative an item is of a given category, and *familiarity* of the word.

Associative frequency has long been used as a measure of the internal structure of a category. An additional predictor of item generation in verbal fluency is typicality (Mervis, Catlin & Rosch, 1976; Rips, Shoben & Smith, 1973; Rosch, 1973). Snodgrass and Vanderwort (1980) found a strong relationship between an item's rank in Battig and Montague, which they interpreted as indicative of typicality, and its rated familiarity. Snodgrass and Vanderwort (1980) themselves collected familiarity ratings for pictures which they asked subjects to rate for familiarity of the concept rather than the label. Another measure of familiarity was proposed by Malt and Smith (1982), who suggested that ease of predication, that is the number of properties that can be generated about an item, would provide a rating of familiarity for an object. They suggested that this would be a better rating of familiarity than ones produced for the label of an item. They based this on the proposal that ease of predication is a good predictor of the rated typicality of an item (Ashcraft, 1978). Malt and Smith (1980) produced both number-of-property scores and typicality ratings. In a post-hoc analysis Hampton and Gardiner (1983) found the two sets of typicality ratings to be higly correlated. Hampton and Gardiner found their number-of-properties scores were most strongly correlated with familiarity and associative frequency and least with typicality. They concluded that the apparent predictive value of ease of predication for typicality ratings was a function of the former's correlation with rated familiarity.

Hampton and Gardiner (1983) found their three measures of familiarity, typicality and associative frequency to be intercorrelated and that familiarity does not greatly influence category structure. They also determined that typicality is a better predictor of whether an item will be generated in a category fluency task than familiarity. Hampton and Gardiner's findings suggest that item generation is more sensitive to cultural variations than typicality. Thus items from the categories clothing, vehicles and furniture are selected from their British norms. The category musical instruments only appears in the Battig and Montague norms, but this seems to be one category with a high overlap between British and U.S English. Items with high rankings in Battig and Montague are taken to be most typical and those with low ranks as atypical, as suggested by Snodgrass and Vanderwort (1980). Through the constraints imposed by frequency and typicality the four categories selected are all non-living ones as there are insufficient atypical high frequency living things.

6.3 Experiment 3 - Category Fluency

6.3.1 Introduction

Verbal fluency, with letters or semantic categories, is commonly used to explore the organization and retrieval of stored information. As a measure of spontaneous speech it can be used to detect verbal adynamia (Stuss & Benson, 1986). Impaired performance is common in aphasia and in dementia where it precedes naming impairment (Benson, 1979). Poor performance on this task is also common in patients with frontal lobe dysfunction where it is attributed to disorganized retrieval processes (Kopelman, 1991).

Referring particularly to category fluency, Rosen (1980) suggested that the task comprises the two components of intactness of the stored items and efficacy of search procedures. This account, however, reflects the difficulty of appealing to explanations that do not have a separate lexical level. Rosen (1980) refers to the first component as the linguistic one, reflecting storage of items in the *semantic store*. With a two-stage model, intactness of representation can be taken as the semantic representation or the lexical one. Poor performance could thus result from impaired semantic storage, faulty semantic-to-lexical access procedures or impaired storage of lexical items.

Category fluency is included here to address a number of issues. It is expected that the PRAD group will produce less items per category than do age-matched controls. This is because it is the most difficult task included here with the only information available being the category name. From the results of Experiments 1 and 2, it is clear that PRAD subjects respond best when there is plenty of information available to them, as in a forced-choice response task. In naming and TOT tasks, where less information is available than in, for example, picture-word matching, PRAD individuals perform worse. It therefore follows, that in a task with even less information available, performance will be worse still.

I am particularly interested in the actual items produced in this task, especially their typicality and the order of generation. These could reveal the way items are organized within categories and how search, location and retrieval of items are taking place. Performance of the PRAD individuals will be compared with that reported for non-impaired subjects, both young and old, to establish any deviations or differences associated with their disorder.

6.3.2 Method

Subjects Participants 1 - 11, 13, 17, 20 and 21, consisted of thirteen female and two male PRAD patients (see Appendix I). Their ages ranged between 74:6 and 89:3, with a mean of 81:10. MMSE scores ranged between 3 and 22, with a mean of 13. The MMSE and category fluency were carried out in the same session. Four age-matched controls performed the same task - C1, C2, C3 and C4 - who were 1 male and 3 females, aged between 72:0 and 80:8, with a mean age of 78:10. Their MMSE scores ranged between 27 and 30, mean 29.25 (Appendix II).

Materials A response sheet containing the four category headings.

Procedure Subjects were told that they would be given the name of a category and asked to name as many items as possible in that category. Category names were presented verbally and responses were recorded both manually and on audio tape. One and a half minutes was allowed for each category. If participants stopped before the end of the alloted time, they were reminded of the category name and encouraged to carry on.

6.3.3 Results

	vehicles		clothing		furniture		instruments	
	P	C	P	C	P	C	P	C
no. zeros*	1	0	3	0	5	0	2	0
maximum**	8	10	12	22	14	22	8	20
mean	3.13	8.5	4.13	16	3.2	12.25	2.53	11
total	47	34	62	64	48	49	38	44

Table 6.1. The number of items generated in each category by the two groups. PRAD (P; n = 15) results on the left of each column, Control (C; n = 4) on the right.

* the number of people who produced no items for a given category

** maximum number of items generated by an individual.

The PRAD group made a total of 282 responses and the controls 197. Responses were defined as appropriate, inappropriate or repetitions based on item inclusions in the norms of Battig and Montague (1969) and Hampton and Gardiner (1983). Appropriate responses were items from the target category, inappropriate were items not from the target category and repetitions were items that had already been said. Of the total PRAD group responses 13.7% were excluded as inappropriate and 17.3% as repetitions, leaving 195 appropriate respnses. Of the total control group responses 1% were excluded as inappropriate and 2% as repetitions leaving 191 (Appendix X contains all responses, with appropriate ones indicated). Novel items were scored when participants offered different labels. Whilst repetitions were excluded, production of more than one name for an item were counted as individual items (e.g. bicycle, push-bike).

The control group generated totals of between 36 and 73 items across the four categories, with a mean of 47.75. The PRAD group generated between 1 and 36 items, with an average of 12.8. The total number of items generated was found to be significantly correlated with the MMSE score for all participants (Pearson correlation coefficient = 0.843, $p < 0.0005$; see Figure 6.1). The four highest points represent the control subjects.

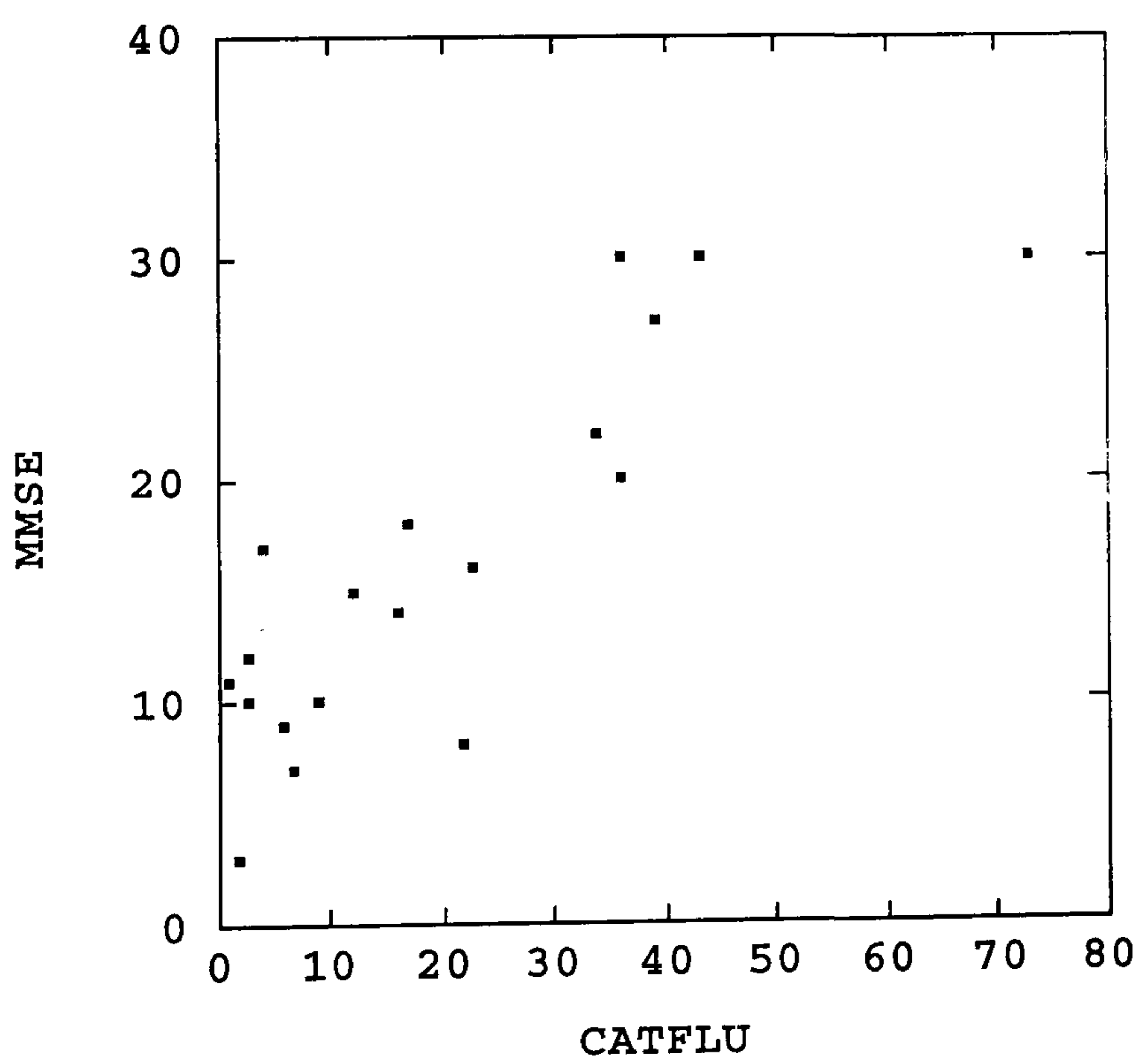


Figure 6.1. Scatterplot showing the relationship between MMSE scores and number of items generated (catflu).

The distribution of item generation across categories is shown in Table 6.1. For all categories, the number of items generated by the two groups differed significantly. For the vehicles category (Mann-Whitney U = 3.00, $p < 0.01$), for clothing (Mann-Whitney U

= 1.5, $p < 0.005$) for the furniture category (Mann-Whitney U = 6.00, $p < 0.01$), and for instruments (Mann-Whitney U = 2.00, $p < 0.005$). In the vehicles category the mean item generation of the controls was 2.71 times higher than the PRAD group, in clothing it was 3.87 times higher, in furniture it was 3.83 higher and in musical instruments it was 4.35 times higher.

Turning from the quantities to the actual words produced, category membership was determined using the norms of Battig and Montague (1969) and Hampton and Gardiner (1983). Items generated in this study are rated typical or atypical based on their Battig and Montague rank or AF. Items were also scored if they occurred in the Hampton and Gardiner norms. Item generation in each category is considered in detail to examine category organization.

In response to the category vehicles, 14 of the 15 PRAD group gave at least one item. Twelve of the fourteen included "car" in their list, with eleven of them giving it as the first item. In Battig and Montague, "car" is the most frequent item and is by far the item most often produced first. Similarly in Hampton and Gardiner car is the most frequently produced item, is given first the most often, and is rated the most typical vehicle. Car also has the highest familiarity rating among vehicles. All four of the control subjects gave car as the first item.

In the clothing category, there is the most difference among subjects. Twelve of the PRAD group produced at least one item, with dress, at four instances, the only item to be produced more than once as first item. In total, dress appeared in seven lists, with neither of the male participants offering it. In both sets of norms, dress is the eighth most frequent item, offered as the first item second most often in Battig and Montague (three instances less than the number one item shirt) and most often in Hampton and Gardiner. "Dress" is rated most typical of the clothing category in Hampton and Gardiner and also has the highest familiarity rating. The control participants each gave a different item as their first.

In the category furniture only ten of the 15 PRAD participants produced any items. Of these ten, eight included chair in their list, with seven giving it as the first item. In the Battig and Montague norms, chair is the first item, which was also given first the most amount of times. In Hampton and Gardiner, chair is just the second most frequently generated item, one less instance than table, but is rated the most typical. It was also given as the first item more often than table, and has the highest familiarity rating. All of the controls included chair, or types of chair, with one giving it as the first item, two giving table first and one giving television.

In the fourth category musical instruments 13 of the 15 PRAD group produced at least one item. Ten people included piano in their list, and in nine of these it was the first item produced. This accords with Battig & Montague where it is the number one item and was given the most times as the first item. Of the 37 items produced, four do not appear in Battig and Montague. These are "bagpipes", "whistle" and two instances of "mouth organ". If the latter is interchanged with "harmonica", then those items not in the norms can be attributed to trans-Atlantic language differences and also, in the case of "whistle", an age difference. Three of the four controls produced "piano", with one giving it as the first item and two giving "banjo". Two instruments not in the norms were produced by a control subject - "Hawaiian guitar" and "piano accordion".

Items generated by less than 10% of subjects, i.e. 44 (Battig & Montague, 1969) and 7 (Hampton & Gardiner, 1983) are taken to be atypical. The PRAD group generated 15 of these (7.7% of valid responses) and the controls 31 (16% of valid responses; see Appendix XI). In addition some items produced by both groups of participants do not appear in either set of norms, such as "nightdress", "caravan", dining table" (see Appendix XII). As these items do not appear in either set of norms they are judged to be atypical also. The PRAD group generated 27 such items and the control group 23. Thus a total of 21.6% of items generated by the PRAD group were atypical and 28.3% of the control group's (see Table 6.2). This compares with an average of 17.3% atypical items across the four categories appearing in Battig and Montague (1969) and 12.63 % across the three categories in Hampton and Gardiner (1983). A further set of items was identified which contained items atypical in one set of norms and typical in the other (see Appendix XIII). For all of these the typicality was found in the British ratings and so they were not counted as atypical.

	vehicles		clothing		furniture		instruments	
	mean	atyp.	mean	atyp.	mean	atyp.	mean	atyp.
PRAD* (n =15)	3.13	19%	4.13	24%	3.2	23%	2.53	15.8%
Control* (n = 4)	8.5	29.4%	16	25%	12.25	32.6%	11	29.5%
B&M (n = 442)	7.04	26.3%	9.5	11.3%	7.25	23%	8.33	26.3%
H&G (n = 72)	8.69	19.6%	13	9%	8.65	11%		

Table 6.2. Average number of items generated and percentage of items that are atypical across the four categories in this study and in the Battig and Montague (1969) and the Hampton and Gardiner (1983) studies.

* Percentages of responses rated atypical include items not in the B&M or H&G norms.

Looking at the order of generation, of the 60 response categories (15 subjects x 4 categories) of the PRAD group, there were ten with no responses. In 42 (94%) of the fifty containing appropriate responses, the first item generated was a typical category member. Among the control group responses 13 of the 16 response categories (81%) had a typical item generated first. Items were classified as typical if they were among the ten most generated items in the norms. This differed from the method used to designate atypicality as the numbers of items produced by less than 10% of subjects far exceeded those produced by 90% or more of subjects. Items falling between these two groups are of moderate typicality.

	total	% valid	mean	typical	atypical	high	low
PRAD	55	28	3.6	55	0	40	15
Control	29	15	7.25	28	1	15	14

Table 6.3. Characteristics of target items of the test battery spontaneously generated in category fluency, Experiment 3.

Each of the PRAD group produced at least one of the items selected as targets for the other tasks in the battery (Experiments 4, 5 and 7), as did the four controls (see Table 6.3). These accounted for 28% and 15% respectively of valid responses made by the two groups. All of the target items generated by the PRAD participants were typical and all but one of those produced by the controls. Both groups generated high and low frequency targets but the distribution of these was much more even in the control group (see Table 6.3). In the PRAD group high frequency targets account for 73% of the targets generated whilst they account for 52% of the controls'.

6.3.4 Discussion

As expected, the PRAD participants, as a group, generated far fewer items than the controls. There was however, quite a variation between individual perfomances and between categories, with severity, as measured by MMSE score, the principle determinant of items generated. Even though the number of PRAD participants was far greater than the number of controls, there was only one category, vehicles, in which the total number of items generated by the PRAD group was greater than that of the controls. Whilst mean item generation by the PRAD group was significantly lower in all categories, in musical instruments it was over four times less, in clothing and furniture it was just under four times less and in vehicles it was under three times less. This variation is independent of the total performance on any given category, such that both groups did best on clothing followed by furniture, whilst vehicles was worst for controls and instruments for the PRAD participants. This accords with the findings of both Battig and

Montague (1969) and Hampton and Gardiner (1983), where more items were generated in the clothing category than any of the others used here. This suggests that the organization of semantic categories in the PRAD participants did not differ from either the elderly controls or the young adults in the other two studies.

Whilst the PRAD group generated fewer items in each category than the controls and the young adults in the norms, the proportion of responses that were atypical was comparable, with variations between categories. The pattern of generation in both groups was very similar to that of the young adults, with typical items generated early in the list and atypical later. Interestingly the proportion of atypical responses generated by both PRAD and control groups was higher than in either Battig and Montague (1969) or Hampton and Gardiner (1983). One explanantion could lie in the difference in time allowed to generate the items. Battig and Montague (1969) allowed 30 seconds and Hampton and Gardiner (1983) 60 seconds for the generation task. With the longer time allowed, the subjects in Hampton and Gardiner's study generated more items than those in Battig and Montague's. In the present study 90 seconds was given as it has been suggested that PRAD performance on fluency tasks may be slower than normals (Ober et al., 1986; see Chapter 2). As typical items are generated early in the list, then with increased time we would expect a greater number of less typical category members to be produced. This was particularly so for the controls.

Hampton and Gardiner (1983) proposed that the best measure of internal category structure is typicality. These findings suggest that the internal category structure of the PRAD subjects is similar to that of the controls. Atypical items were commonly produced later down the lists when the most obvious (typical) items had been produced. This suggests that in the patients who were less deteriorated there were the usual associations and contents to their semantic stores.

These data, therefore, do not support the idea of a semantic storage disorder in PRAD. In addition the proposal of Chan et al. (1993), that in the impaired semantic store new and unusual associations develop, is also not supported. Rather the reduced generation of appropriate items by PRAD subjects seems to lie more in difficulties with the processes involved in carrying out the task. The number of inappropriate responses generated suggests that problems may lie in constraining the search procedure. This is supported by the high number of repetitions which suggests a failure in the ability to self-monitor speech, a process reported to deteriorate in moderately severe PRAD (Bayles, 1982). This may also be related to the noted impairment of short term memory in PRAD.

6.4 Experiment 4 - Naming and Comprehension 2

6.4.1 Introduction

Naming and comprehension, as measured by word-picture matching, play a crucial part in attempts to measure response consistency in PRAD. In picture naming a visual input is provided to be matched with a stored semantic representation of the item and also a lexical item. The appropriate phonological code is also retrieved and output. Failure to name a visual stimulus may occur for several reasons. One explanation is that there is a problem at the input stage with visual stimuli processing. A second account is a problem translating between the input and the stored semantic representation. A third possible explanation is the loss of the item itself from semantic storage. Another account is loss of links between the semantic representation and the item's label. A fifth possibility is the loss of the item's name from the lexicon. Yet another account is a problem translating from the lexical representation to the phonological and thence to output.

The combination of naming and picture-word matching is useful for exploring these various accounts. Where items are not named it is possible to investigate whether the visual representations themselves and the names are both comprehended. Successful between-category word-picture matching demonstrates first that the pathways from visual input to semantic representation are intact, and second that the passage between auditory input and semantic representation is functional. In addition, between-category word-picture matching indicates at least category knowledge of the target item. Success at within-category choosing indicates all of the above plus demonstrating that the semantic representation is (largely) intact. This combination of tasks therefore provides information to examine several of the possible accounts for naming failure in one set of data.

6.4.2 Method

Subjects The PRAD participants S1, S2, S3, S4, S5 and S6, all did these tasks. They are all female and were aged between 79:10 and 85:9, with a mean age of 82:4 years. The four control subjects, C1, C2, C3 and C4, also took part. They are 1 male and 3 females, aged between 72:0 and 80:8, with a mean age of 78:10.

Materials As described above 24 colour photographs were used, six from each category. Phonological and perceptual distractors were omitted because in Experiment 1 there was no evidence that they were selected (erroneous responses were more likely to be "don't know").

Procedure In the naming component, subjects were shown each photograph in turn and asked to name the item. No clues were given, but participants were encouraged to give a response, even if they were unsure. Responses were rated using the system devised for Experiment 1 (see Chapter 4).

The comprehension task had two parts, between-category picture-word matching and within-category matching. On the between-category part, participants were shown arrays of four photographs and asked to point to the target named by the experimenter. Each set of four contained an item from each of the four categories, selected to include both a high and a low frequency typical item, and a high and a low frequency atypical item. On the within-category element, four photographs of items from the same category were presented together, again selected to include both a high and a low frequency typical item and a high and a low frequency atypical item.

6.4.3 Results and Discussion

Naming. The control subjects made 91 out of 96 (95%) correct responses overall, giving a mean of 22.75. The five responses not containing the target comprised one unresolved TOT, one visual error, one ambiguous visual/semantic error, one semantic coordinate and one "don't know". The naming performance of the PRAD group was impaired in comparison to that of the controls. The highest number of correct resonses by a PRAD participant was 17 and the lowest 10, with a mean total of 14.8. Of the total 144 items there were 89 (62%) containing the correct target (response categories 1, 2, and 3 - see Figure 6.2). Eleven of the 55 incorrect responses were unrelated or don't knows. Of the remainder 22 had some visual relationship with the target and 23 some semantic relationship (both including ambiguous visual/semantic responses). There were six unresolved TOTs and no perseverative or phonological errors. More than one third of the non-target responses were visually-related errors in spite of using colour photographs.

Significantly more high frequency items than low were named ($t(5) = 6.29$, $p < 0.005$). In addition, significantly more typical than atypical were named ($t(5) = 7.90$, $p < 0.001$). Purely visual errors, as opposed to ambiguous visual/semantic ones, were unrecognised items and all were atypical.

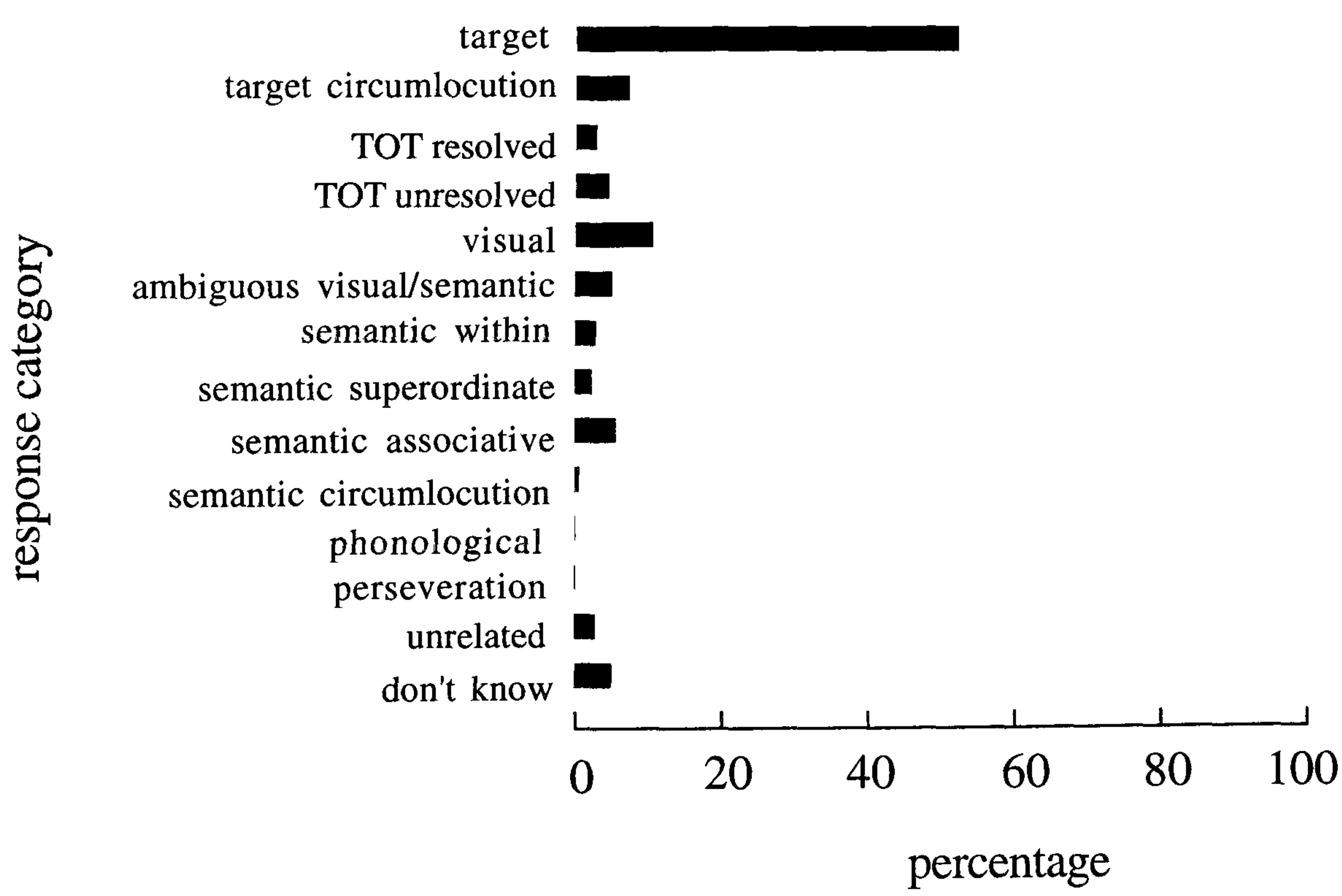


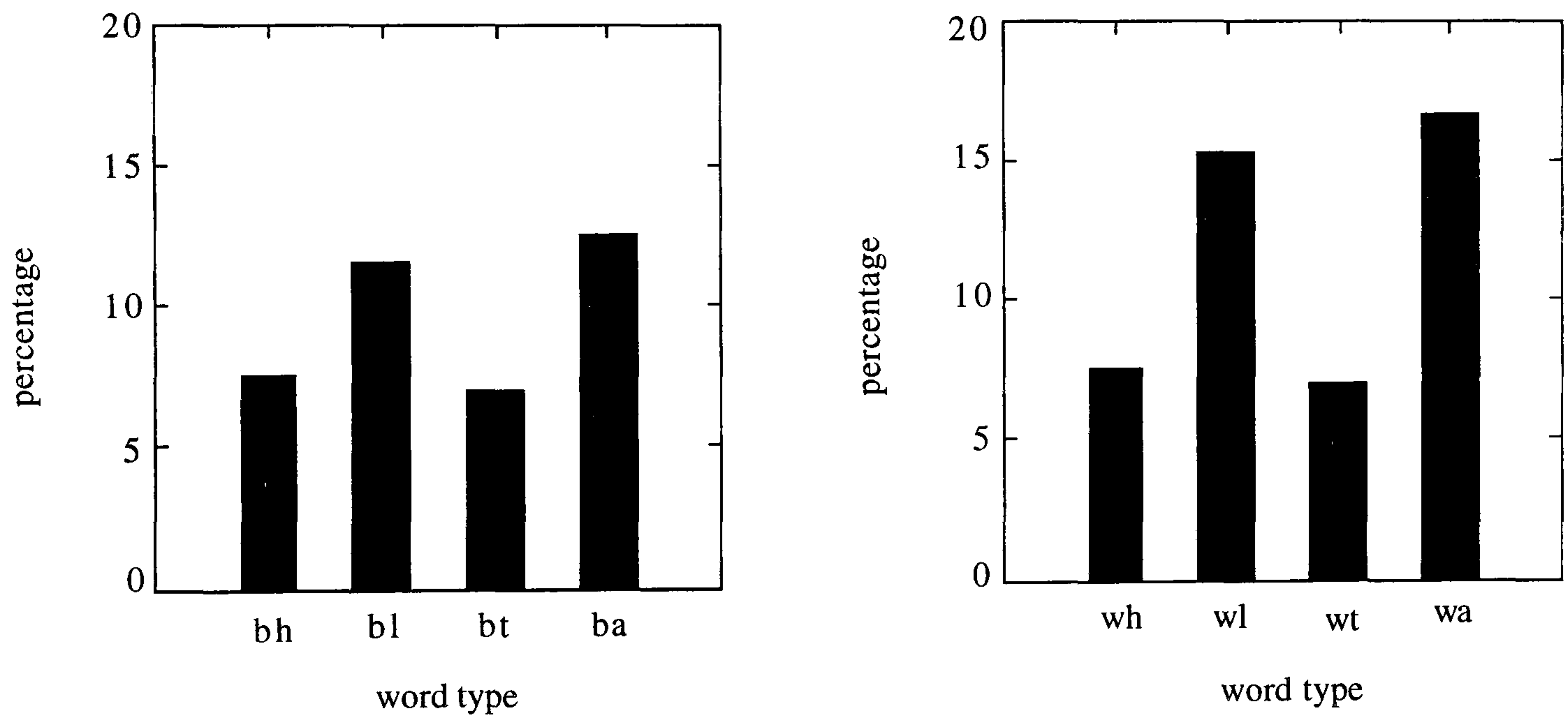
Figure 6. 2. Distribution of PRAD naming responses across all response categories

Comparisons of the frequency, imageability and syntactic category were made between the target words and the substitutions produced in the visual and semantic errors, the TOT states and circumlocutory responses. Sometimes more than one word was produced in a response and the total number of target-substitute pairs was 50 (Appendix XIV). Frequency ratings for both members of 43 of these pairs were available in Francis and Kuçera (1982). There was no significant difference in frequency between the target-substitute pairs for either the visually related (mean target frequency 11.91, mean substitute frequency 18.74; $t(22) = 1.06$, $p > 0.05$) or semantically related (mean target frequency 8.33, mean substitute frequency 43.14; $t(20) = 1.45$, $p > 0.05$) pairs. Imageability ratings for both members of 12 of the target-substitute pairs were available from the Oxford Psycholinguistic Database (Quinlan, 1992) and there was no significant difference between the two sets of words (mean target imageability 5.93, mean substitute imageability 5.98; $t(11) = 2.35$, $p > 0.7$). All of the targets and all of the substitute words were nouns.

The mean semantic relatedness of the target-substitute pairs produced in Experiment 9 supported the distribution of responses across the categories (see Appendix XIV). Target-substitute pairs in the target circumlocution and both TOT responses received a mean semantic relatedness rating of 2.82. Responses falling into the ambiguous visual/semantic, semantic-within-category, semantic superordinate, semantic associative and semantic circumlocutory received a mean semantic relatedness rating of 3.19. Target and visually related substitute pairs received a mean rating of 1.29, confirming that they were truly visual errors.

As in Experiment 1, PRAD naming performance is impaired relative to controls. When items were not named correctly, then responses were either visually based errors or semantically related to the target. This suggests that some items were not being recognised from the visual input whilst others were recognised but that name retrieval was not successful.

Comprehension. This part of the experiment was only administered to one control participant who performed at ceiling. A one-way related analysis of variance across the naming and two comprehension tasks revealed that the PRAD participants performance differed significantly where the mean targets named was 14.8, mean number of targets correct on within category comprehension 21.27 and mean on between category 21.67 ($F(2, 10) = 35.45, p < 0.0005$). Naming performance was significantly worse than both comprehension tasks at the $p < 0.0005$ level. On the between category 90.3% of responses were correct and on the within 88.2%. Performance on the two comprehension tasks was not independent with items responded to the same way on each ($t(23) = 2.48, p < 0.05$).



6.3a Between category matching

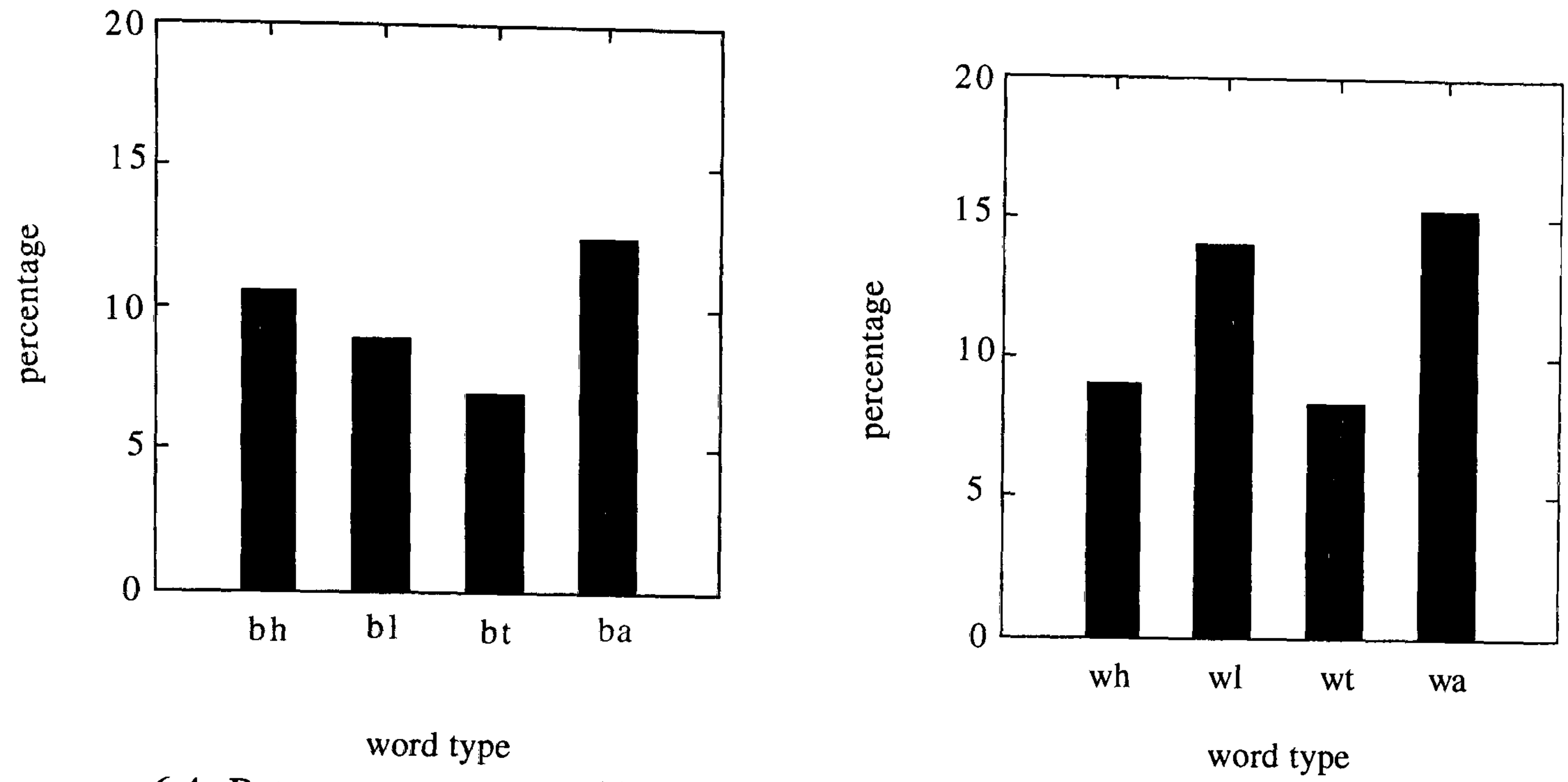
6.3b Within category matching

Figure 6.3. Percentage of failed targets on between category (6.3a) and within category (6.3b) comprehension tasks.

Key: bh = between high; bl = between low; bt = between typical; ba = between atypical.
wh = within high; wl = within low; wt = within typical; wa = within atypical.

On the within-category task, 127 out of the 144 items were correct. More low frequency targets than high were failed and more atypical than typical (Figure 6.3b) but neither were significantly different ($p>0.05$). All of the incorrect responses were semantic distractors rather than "don't know" or no response. More of these were low frequency than high (see

Figure 6.4a) and more were atypical than typical (see Figure 6.4b) but again not significantly.



6.4a Between category matching   6.4b Within category matching

Figure 6.4. Percentage of substitutes of each word type on between category comprehension (6.4a) and within category comprehension (6.4b).

Key: bh = between high; bl = between low; bt = between typical; ba = between atypical.
wh = within high; wl = within low; wt = within typical; wa = within atypical.

On the between-category task 130 out of 144 were correct. More low than high targets were failed (see Figure 6.3a) and more atypical than typical but not significantly. The incorrect responses comprised equal numbers of high and low frequency (see Figure 6.4a) and more atypical than typical (see Figure 6.4b) but not significantly.

As significantly more items were comprehended than named, failure in naming cannot be interpreted as loss of the item. The results from the naming and comprehension tasks suggest that evidence of intact semantic concept knowledge may not always be gained from naming tasks alone. That the purely visual errors arose for atypical items suggests that they were visually unfamiliar but does not reveal that the concepts were not in place. In addition, the semantic relatedness of many of the errors could be interpreted as loss of specific knowledge in the face of retained category knowledge. However, the lack of a frequency effect in the substitutions does not support this interpretetation.

6.5 Experiment 5 - Tip-of-the-tongue 2

6.5.1 Introduction

This study is a repetition of Experiment 2 using definitions of the 24 target words detailed at the beginning of this chapter. The use of auditory presentation allows for comparison with results from tasks such as naming which use visual input en route to lexical access. This is important for evaluating the explanation that impaired output results from impairment of underlying representations. This is because disordered output may actually reflect input problems. For this reason the TOT methodology is particularly useful within a combination of tasks.

Experiment 2 yielded interesting patterns of responding among the PRAD participants with under half of their responses containing the target word. However, their alternative responses indicated that the reduced level of target production was not the result of loss of item knowledge. Indeed the majority of non-target responses were semantically related to the target items. In general, though, the semantic relationship between the two was weaker among the PRAD responses than among the controls' which suggests that the links between concepts and labels are weakened or that the inhibitory processes that prevent items with similar semantic specifications receiving activation inappropriately are impaired.

6.5.2 Method

Subjects Eight individuals with PRAD, S1, S2, S3, S4, S5, S6, S7 and S11 all took part. They are all female and were aged between 74:7 and 89:4, with a mean age of 81:11 years (Appendix I). Four control subjects, C1, C2, C3 and C4 also carried out this task. They are one male and three females aged between 72:1 and 80:9, with a mean age of 78:11 (Appendix II).

Materials Definitions of the 24 words were compiled from the Concise Oxford Dictionary (1991) and from definitions provided by three volunteers (see Appendix XVIII).

Procedure Participants were told that they would be read a description of an item that they would then be asked to name. The experimenter read out the definitions at least twice and participants' responses were recorded both manually and on audio tape. There was no visual presentation of the stimuli in this task.

6.5.3 Results

Responses are classified into the same five response categories as in Experiment 2. The control group made over 85% correct responses with a mean of 20.50 (range 19 - 23), which compares with only 40% for the PRAD group, mean 9.62 (range 4 - 17; see Table 6.5). The difference between the groups is significant (Mann-Whitney U = 0, $p < 0.005$). The PRAD group also made significantly more "don't know", with 0 recorded by the controls and a mean of 4.25 for the dementia group (Mann-Whitney U = 0, $p < 0.005$). The PRAD group also made more of a third type of response than the controls, that is constructive search, where the means were 3.625 and 0.5 respectively (Mann-Whitney U = 4, $p < 0.025$). In this study the percentages of TOT responses made by the PRAD (9%) and the controls (5%) are a little smaller than those in Experiment 2 (PRAD 12%, controls 5.5%). As in Experiment 2, the PRAD group responses are spread across the response categories much more than those of the controls' (see Table 6.5). Because of the small size of the control sample and the distribution of their responses, I confine the remaining analysis to only the PRAD group's responses.

Target responses. Target item production immediately in response to the definition is only 40%. However, the overall instance of target item production across all responses is higher than this because 75% of resolved TOTs and 34% of constructive search responses result in the target item. This gives a total of 96 (50%) responses containing the target item. Significantly more high frequency targets were produced than low ($t(7) = 3.81, p < 0.01$), and more typical targets are produced than atypical ($t(7) = 3.99, p < 0.005$).

Response type	Control group	PRAD group
	total 96	total 192
Correct target word	82 (85.5%)	77 (40%)
Don't know	0 (0%)	34 (17.75%)
Resolved TOT	2 (2%)	12 (6.25%)
Unresolved TOT	3 (3%)	5 (2.75%)
Own-target word	7 (7.25%)	35 (18.25%)
Constructive search	2 (2%)	29 (15%)

Table 6.5. Comparison of responses made by Control and PRAD group, by absolute number and percentage

Don't know. The distribution of don't know responses differs across word types, with 82% produced to low frequency targets ($t(7) = 4.93, p < 0.005$). In addition, significantly more don't know responses are to definitions of atypical items (atypical mean = 2.75, typical mean = 1.5; $t(7) = 3.42, p < 0.05$).

TOT responses. As in Experiment 2 both high and low frequency items elicited TOTs (see Table 6.6) with 71% produced to low frequency targets although this difference is not significant ($p > 0.1$). Both typical and atypical targets elicited TOTs with atypical eliciting significantly more (typical mean = 0.75, atypical mean = 1.37; $t(7) = 2.37, p < 0.05$). Of the eight words that induced TOTs only four have imageability ratings. As in Experiment 2 there is no significant correlation between frequency and imageability in the target words ($r_p[14] = +0.45$). Only one response, an unresolved TOT, contains partial phonological information ("cur, [con] something" for *curtains*).

response	TW	DK	TOT	OTW	CS
HT	27	3	1	12	5
LT	21	9	6	6	6
HA	17	3	4	6	10
LA	12	19	6	11	8

Table 6.6 Distribution of responses for the different word types.

TW = target word; DK = don't know or no response; OTW = own-target word; CS = constructive search.

TOT relatives. Relatives of the target words occurred in 10 of the 17 PRAD TOTs, producing 18 relatives. These are all words and all nouns (see Appendix XVI). Table 6.6 shows the mean frequency of the targets and relatives. Mean frequency is calculated using only the pairs where both members have a frequency rating of at least 1 per million in Francis and Kuçera (1982). Targets and TOT relatives do not differ significantly in frequency (PRAD $t(13) = 1.73$, $p > 0.1$). In addition there is no difference in the distribution of targets and relatives between typical and atypical (see Table 6.7; Fisher's exact $p > 0.5$).

One of the TOT relatives received a semantic relatedness rating classifying it as unrelated. This is "hassock", produced to the definition for *hammock*. I class this response as a mixed semantic and phonological relative of the target for although the semantic relatedness rating is below 1.5, "hassock" occurs in the furniture category in Battig and Montague (1969). Indeed, "hassock" occurred more times as an instance of this category than *hammock*. The mean semantic relatedness rating of the TOT relatives is 2.889 (range 1.4 - 3.86) which is significantly higher than that of the random word pairs (1.16; Mann-Whitney U = 3, $p < 0.0005$), confirming the semantic relationship between targets and TOT relatives. I use Battig and Montague's (1969) semantic category norms as a guide to the nature of this relationship. Not all of the items occur in Battig and Montague but the patterns of item generation provide indicators for classifying them. Using this method all of the relatives are co-ordinates of their respective targets.

	mean freq.	mean im.		mean freq.	mean im.
target	12.14	*	TOT	56.93	*
target	22.73	6.029	OTW	49.5	5.678
target	36.5	5.962	CS	60.09	5.965

Table 6.7. Mean frequency and imageability ratings for the target and non-target response words

Note: * Too few word pairs with imageability ratings.

Key: Mean freq. = mean frequency; mean im. = mean imageability; TOT = TOT relatives; OTW = own-target words; CS = constructive search words.

Own-target words. A total of 32 own target words were produced. Table 6.7 shows the mean frequencies for the targets and own-target words which are not significantly different ($p > 0.1$). There is also no significant difference in the imageability ratings of targets and own-target words where ratings are available ($t(5) = 1.87, p > 0.1$). There is a significant difference in the distribution of own target words to targets by typicality (Table 6.8; Fisher's exact $p > 0.05$). All of these 32 own-target words are nouns and include 2 proper nouns ('Mini' for *car*, 'Pullman' for *train*).

Three of the target-own target pairs received ratings below 1.5 (see Appendix XVII). One of these 'table' for *trousers*, is judged a phonological relative of the target using the criteria of Harley (1984) of shared initial letter and number of syllables. The other two ('squad' for *trumpet*, 'confirmation' for *turban*) are very weakly associated, at least with items in the definition (see Discussion). The mean semantic relatedness rating of the own target words is 2.76 (range 1.0 - 3.93). This is significantly higher than the rating for the random word pairs (Mann-Whitney U = 56, $p < 0.0005$). Excepting the three items rated semantically unrelated, the remaining 29 are all category co-ordinates, using the Battig and Montague (1969) category inclusions (see Discussion).

T - S	TOT rels n = 17	OTW n = 29	CS n = 30
Typ - Typ	2	2	5
Typ - Atyp	2	12	4
Atyp - Atyp	9	6	14
Atyp - Typ.	4	9	7

Table 6.8 Patterns of substitution for typical and atypical targets of TOT relatives, OTW and CS words.

Key: T = target; S = substitute.

Constructive search words. These are words produced by subjects as they actively search for the response to the definition, but are not so sure of the target word that they feel themselves to be in a TOT state. The 29 constructive search response trials yielded a total of 34 words (see Appendix XVIII). The frequencies of targets and constructive search words do not differ significantly ($t(21) = 0.86$, $p > 0.4$). The mean difference between imageability ratings of the targets and constructive search words (0.003) suggests they do not differ on this dimension (Table 6.7). There is also no significant difference between the distribution of typical and atypical responses to the targets (Fisher's exact p > 4). The 34 constructive search words are all nouns, including one proper noun.

Four of the 34 constructive search words received semantic relatedness ratings below 1.5. Of these one ('Cymbeline') is judged to be a mixed semantic and phonological error (through examination of the whole response; see Discussion), one a perseveration ('turban' for *rocket*) and 2 unrelated ('duvet' for *bath*, 'loofah' for *turban*). The constructive search words are significantly semantically related, with a mean of 2.58 (range 1 - 3.86; Mann-Whitney U = 102, $p < 0.0005$). Four of the semantically related constructive search words are judged to be associates rather than category co-ordinates of their targets. These are “river”, swimming baths” and “swimming pool” for *bath* and “station” for *train*. The remaining 26 are category co-ordinates using Battig and Montague’s (1969) category inclusion (see Discussion).

6.5.4 Discussion

As in Experiment 2 the PRAD participants produced significantly fewer targets in response to the definitions than the age-matched controls. The PRAD group also made "don't know" responses which the controls did not. In addition the PRAD group made more constructive search responses than the controls. The low number of immediate target responses and the number of TOT and constructive search target responses suggest that the PRAD patients are less efficient at retrieval. In addition, the target words they produce are more likely to be high frequency and typical than low frequency or atypical. Similarly more don’t know responses are to definitions of low than high frequency targets and to definitions of atypical items. This suggests a problem with the representations of low frequency and atypical items. If this is the case we would expect substitutes to be higher frequency than their failed targets. However, there was no difference in the frequency of targets and the words offered as substitutes either in TOT states, as own targets or when searching for the target. In other words, low frequency targets are substituted with other low frequency words. There was also no frequency effect in the TOT relatives or the own target words in Experiment 2 (TOT 1). However, there was in the constructive search words. The explanation given there relates to the nature of the search process, where participants generate words related to the target in an attempt to cue the target. As it is difficult to predict which related words will be produced in a constructive search it seems likely that different target words and groups of targets will produce related words across the whole range of frequencies. This could explain why in Experiment 2 the generated relatives are higher frequency than the targets but not the ones in this study.

In addition to the lack of frequency effects among non-target words and their targets, their was no effect of typicality in any of the three non target response types. However, the distribution of typical and atypical TOT relatives does not follow this prediction. For the own target words there is a significant difference in the distribution in that typical targets are substituted by atypical own targets and atypical by typical. The suggestion of a problem with the representations of low frequency words and atypical category members would particularly give rise to the prediction that non target words will be more typical than their targets in constructive search responses. This is because if the target is not retrieved in response to the definition, then the presence of category information in the definition should lead to generation of items typically associated with the category. That this is not so suggests that where constructive search is occurring, participants are operating on more than just the category.

There is further evidence for this in the finding that the majority of non-target responses are semantically related category co-ordinates of their targets. There are only two items that are not related in any way. Among the items rated as unrelated three are particularly interesting. One is the own target word "squad" for *trumpet.* The definition of trumpet contains the phrase "used by the cavalry". This response suggests that only part of the definition was responded to but this was not the category part. Similarly the own target word "confirmation" for *turban* where the definition for turban contains the phrase "religious [or cultural] reasons". These responses are revealing about how and how much of the definitions are used to make a response. Both suggest that the category is not the primary information in a definition. However, an alternative explanation arises from the noted short term memory problem in PRAD. In both of the above definitions the category information occurs at the start of the definition. It could be that by the end of the definition information at the beginning has been forgotten. However, that the majority of non target responses are category co-ordinates of their targets does not support this, rather it suggests that responses based on fragments of definitions are to the most salient features.

The third response rated unrelated that is of interest is “Cymbeline” for *tambourine.* I judge this to be a mixed semantic and phonological error based on what else was said. This was “something like Cymbeline, cymbals”. My interpretation is that both cymbals and tambourine came to mind and, through the noted word superiority effect in substitutions (Dell, 1986; Harley, 1984, 1993, Martin, Weisberg & Saffran, 1989, Stemberger, 1985), came together as Cymbeline. This, then, appears to be a straightforward mixed speech error rather than indicative of underlying semantic disruption.

One final issue is the lack of superordinates among non-target responses. If language disorder in PRAD is the result of underlying semantic disturbance characterised by the loss of specific item knowledge (Flicker et al, 1987; Hodges et al, 1991; Martin & Fedio, 1983), then there should be a large amount of superordinate substitutions. One problem with exploring this arises from the terminology. In Battig and Montague’s (1969) category norms, the category names can be considered to be superordinates. Thus boat and barge are co-ordinates of the superordinate category vehicles, as are car and Mini. However, using the three level hierarchy of Rosch et al. (1976), *barge* and "Mini" are subordinates of the basic level categories "boat" and *car* whilst vehicles remains the superordinate. Thus, depending on the interpretation of the terms superordinate and subordinate, there is an example of a superordinate"boat" substituting for a subordinate *barge* and a subordinate "Mini" substituting for a superordinate *car.* The existence of both of these suggests there is no systematic specific-to-general impairment of semantic storage. When this is taken with the lack of a typicality effect in substitutions, this study does not provide any evidence in support of the notion of impairment of underlying semantic representations.

Chapter 7

Definitions: Experiments 6 and 7

7.1. Introduction

This chapter contains two definition experiments. The first is a study with young healthy adults who produced definitions of the 24 target words described in Chapter 6. Their responses were analysed to identify the components of satisfactory definitions. Experiment 7 contains the definitions made to the same words by the PRAD participants. Their responses were independently rated and are compared with those of the young controls.

7.2 . Experiment 6 - Definitions

7.2.1 Introduction

Producing definitions of words requires metalinguistic skill (Bialystok & Ryan, 1985). As such it relies on two aspects of cognitive processing. The first of these is *analyzed knowledge*. This is the ability to represent and access both the meaning and the structure of knowledge (Bialystok & Ryan, 1985). Concern with just the meaning and not the form of the definition indicates unanalyzed knowledge. The second factor is *cognitive control.* This deals with the selection and retrieval of knowledge and its subsequent co-ordination (Bialystok & Ryan, 1985).

That definitions are metalinguistic in nature is one of four features proposed as characterising definitions (Watson, 1985). The others are second, that there is a conventional linguistic form for definitions. For nouns this consists of a statement of semantic equivalence (Bierwisch & Kiefer, 1969), such that 'NP1 is NP2'. In this NP1 (the *definiendum*) is a paraphrase or semantic equivalent of NP2 (the *definiens*), with the copula *is* signalling the relationship. Third, that definitions contain conventional meanings of words. This is distinct from the true meanings and reflects the conventional usage made of any given word. Fourth, that definitions are explicit expressions of word meanings that are mainly implicit in discursive language.

Aristotelian definitions characterise the definitions of nouns made by adults and older children with sufficient competence in a language (Litowitz, 1977; Snow, 1990). These definitions take the form of providing the category to which an item belongs and the primary or salient features that distinguish it from other category members.

The development of definitions in children shows an age-related pattern with superordinates excluded until approximately 10 or 11 years of age (Benelli, Arcuri, & Marchesini, 1988; Litowitz, 1977; Wehren, Lisi, & Arnold, 1981). There are three plausible explanations for this. One relates to the depth and availability of taxonomic knowledge. The use of superordinates in definitions correlates with the taxonomic use of superordinates (Benelli, 1988). However, whilst young children do not include hierarchical superordinate information in their definitions, pre-schoolers can give the correct response to questions such as "is a cat an animal?" (Benelli, 1988; Watson, 1985). The second explanation stems simply from lack of familiarity with the conventional form of definitions and lack of opportunity to practice this (Snow, 1992). The third account relates to the emergence of metalinguistic skills. This is indicated by performance not only on definitions but other tasks noted for measuring metalinguistic skills such as sentence correction and grammaticality judgements (Bialystok & Ryan, 1985).

Whilst intuitively appealing as a research method, definitions are particularly difficult to analyse. Quantitative data are hard to derive, as are objective measures to compare subjects' responses with. This experiment is an attempt to deal with these problems. To adequately examine what the definitions produced by the PRAD participants reveal about their underlying semantic knowledge requires some idea of what features are typically produced in definitions of the target items. In addition, an assessment of the PRAD participants' ability to define the items needs to be seen in the context of non-dementing adults' ability. Thus in this experiment, a group of non-dementing adults define the same items. Their responses are rated for adequacy and those definitions rated satisfactory are further analysed in an attempt to identify the key defining features of each item.

7.2.2 Method

Subjects. Thirty eight first year undergraduates in Psychology took part. Their ages ranged between 18 - 46, with a mean of 20:9. Their mean years of education were 13.5, with a range of 11 - 14. Subjects were volunteers recruited from a first year Methods class.

Materials. A two page booklet containing the 24 target words with space between each to write a definition.

Procedure. Participants were instructed to write a definition for each word as clearly and concisely as possible. Definitions were to be such that, should the proverbial visitor from Mars appear, he/she/it would recognise the items from the definition alone. Participants were allowed as much time as they wanted; this ranged between 15 and 38 minutes.

The definitions produced were rated by 2 independent raters using a 5-point scale. Rating instructions were as follows:

Please read the following descriptions and then look at the list of single words below. Can you please indicate on the scale how good you think the definition is for the target word using the following key:

0 this wouldn't make me think of the target at all;

1 minimal information is contained, such as the category;

2 several possible targets are suggested;

3 one or two targets seem most likely;

4 this directed me to the target.

Example: Target = carrot

A thing with four legs	0
A vegetable	1
A root vegetable	2
A long root vegetable	3
A long orange-coloured root vegetable	4

Where there was disagreement between the raters, a third person rated just those items. The mean rating for all items was calculated. Following this, all definitions judged adequate, those with a mean of 3.5 or more, were examined to find the essential features for defining each item. For ease of comparison with the tasks in Chapter Five, the total ratings in this and Experiment 7 were scaled down to be out of 24.

7.2.3 Results and discussion

The highest rating given to a set of definitions was 21.97 (out of a maximum 24) and the lowest 17.27 (see Table 7.1).

	highest	lowest	mean	median	mode
total rating	21.97	17.27	19.608	19.625	----
no. adequate	16	6	10.289	----	6

Table 7.1. Description of ratings for sets of definitions and for those scored adequate.

The highest rated set took 25 minutes and the lowest 29 minutes. Overall there was no relationship between time taken and total rating achieved. The definition ratings were examined in terms of the four different word types (see Table 7.2). A 2-way (frequency X typicality) related analysis of variance revealed a significant main effect of typicality ($F(1, 37) = 58.41, p < 0.0005$) but not frequency ($p > 0.25$) and there was no significant interaction effect ($p > 0.3$). Post-hoc Tukey tests revealed that low frequency atypical words were significantly better defined than each of the other three word types ($p < 0.0005$) and that high frequency atypical words were significantly better defined than either low frequency typical or high frequency typical words.

	HT	LT	HA	LA
total of ratings	174.77	178.37	188.7	203.95
no. of adequate definitions	57	76	110	148

Table7.2 Total ratings and number of adequate ratings for each word type.

There were 391 adequate definitions produced, constituting 43% of all definitions. Of the 57% of definitions scoring below 3.5, only one scored 0, though six scored only 1, meaning that minimal information was provided. The one that scored nothing appeared to be the result of a misreading of the target as *coach* elicited the definition for a *coat*. As would be expected there was a high correlation between total score and number of adequate definitions produced ($r_p = +0.912, p < 0.0005$).

The mean number of adequate definitions produced, 10.26 out of a possible total of 24, is perhaps less informative than the modal score of 6 (see Table 7.1). Thus whilst some participants were able to adequately define two-thirds of the items, the most commonly defined proportion was only one-quarter.

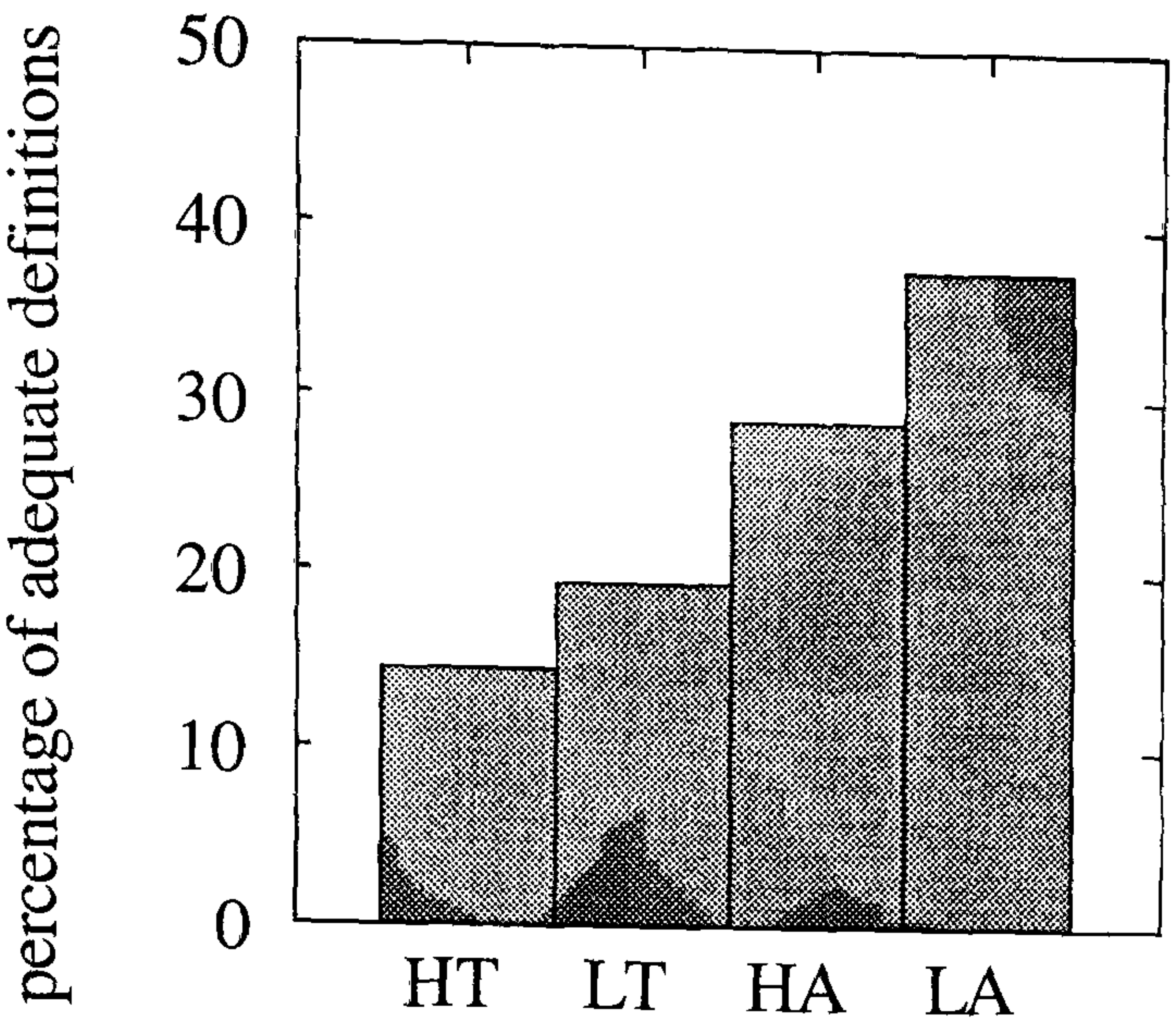


Figure 7.1 Mean number of definitions rated adequate for each word type.

key: LA - low frequency atypical; HA - high frequency atypical; LT - low frequency typical; HT - high frequency typical.

Word type. The distribution of adequate definitions was not evenly spread across the four word groups (see Figure 7.1). A 2-way (typicality X frequency) related analysis of variance across the total scores received by adequate definitions (3.5 or above), revealed a significant main effect of typicality ($F(1, 37) = 84.94$, $p < 0.0005$) and a significant interaction ($F(1,37) = 5.75$, $p < 0.05$) but no main effect of frequency ($p > 0.1$) with no interaction. Post hoc Tukey tests revealed significant differences between the mean scores of the adequate definitions of each group of words at the 0.0005 level, except for between high frequency typical and low frequency typical. Thus more adequate definitions were made to the low frequency atypical words than the other three word types.

The components of the adequate definitions were classified following the scoring criteria of the WAIS-R Vocabulary test. The following six elements were identified:

Good synonym; major use/function; primary (defining) features; general classification; minor use; secondary (non-defining) features.

Type	total defns.	good synonym	major use	primary feature	category	minor use	secondary feature
HT	57	1 (1.75)	37 (65)	57 (100)	51 (89.5)	1 (1.75)	37 (65)
LT	76	6 (8)	44 (58)	76 (100)	60 (79)	2 (2.6)	57 (75)
HA	110	8 (7)	75 (68)	101 (91)	53 (48)	5 (4.5)	66 (60)
LA	148	---	105 (71)	146 (99)	89 (60)	1 (0.7)	112 (76)
Total	391	15 (3.9)	261 (67)	380 (97)	253 (65)	9 (2.3)	272 (70)

Table 7.3. Number of definitions containing each element by word type. Percentage of adequate definitions containing each element in parentheses.

key: LA - low frequency atypical; HA - high frequency atypical; LT - low frequency typical; HT - high frequency typical.

Each adequate definition was examined for which of these elements it contained and how many examples of each (see Table 7.3). The number of components comprising the adequate definitions ranged between two and twelve, though this latter reflects a response consisting of two definitions. This occurred on several occasions as some of the items have more than one meaning (*cap*, *coach*, *rocket*, *recorder*). The mean number of components per adequate definition was 4.68. Almost all of the adequate definitions (97%) contained distinguishing features of the target item (see Table 7.3). This pattern was common to all word types. The majority of definitions also contained secondary features (70%). The highest occurrence of these was in the adequate definitions of low frequency atypical words (80%). Category information and major functions were about equally supplied in two-thirds of all adequate definitions (65% and 67% respectively). Among the word types high frequency typical contained by far the most instances of category information (89%) and high frequency atypical the least (49%). Instances of major usage were more evenly distributed across word types. Very few adequate definitions contained synonyms or minor functions (3.9% and 2.3% respectively).

Among specific word types synonyms were most found in definitions of low frequency typical words (8%) and not at all in low frequency atypical. Instances of minor usage of items were found in each word type.

Type	total defns.	good synonym	major use	primary feature	category	minor use	secondary feature
HT	57	1 (1)	47 (1.4)	98 (1.7)	51 (1)	1 (1)	68 (1.8)
LT	76	6 (1)	44 (1)	181 (2.4)	60 (1)	3 (1.5)	99 (1.8)
HA	112	8 (1)	103 (1.3)	195 (1.9)	62 (1.1)	5 (1)	103(1.5)
LA	146	---	110 (1)	336 (2.3)	87 (1)	1 (1)	159(1.4)
Total	391	15 (1)	304 (1.2)	810 (2.08)	260 (1.03)	10 (1.13)	429(1.6)

Table 7.4. Total number of instances of each element for each word type. Mean number of occurrences per containing definition in parentheses.

Not only were primary features contained in the majority of adequate definitions, a greater amount of these were provided than any of the other components (see Table 7.4). Across word types, significantly more were given in definitions of low frequency items than high frequency ($t(22) = 2.19, p < 0.05$). The mean numbers per definition for both primary and secondary features were higher than for any of the other components. If synonyms were provided there was only one per definition. Similarly, only one category (general classification) was given per definition, except where items belonged to more than one category as explained above. This applies also to major uses, where only one instance was most commonly given.

Categories. In addition to examination of the distribution of defining elements by word type, their distribution by category was also explored. The total number of adequate definitions produced are not evenly distributed across the four categories (see Table 7.5). Approximately 60% of the total 228 definitions of items of furniture were rated adequate, whilst only 30% of those for musical instruments were. For both vehicles and clothing about a third of all definitions received adequate ratings.

Type	total defns.	good synonym	major use	primary feature	category	minor use	secondary feature
F	136	12 (8.8)	99 (72.8)	132 (97)	52 (38)	6 (4.4)	99 (73)
V	96	2 (2.1)	68 (71)	93 (96.8)	83 (79)	2 (2.1)	61 (63)
C	92	----	41 (45)	89 (96.7)	59 (64)	1 (1.1)	58 (63)
I	67	1 (1.49)	53 (79)	66 (98.5)	59 (88)	-----	54 (81)
Total	391	15 (3.9)	261 (67)	380 (97)	253 (65)	9 (2.3)	272 (70)

Table 7.5 Numbers of definitions containing each element by category. Percentage of adequate definitions containing each element in parentheses.

Key: F = furniture V = vehicles C = clothing I = musical instruments

The major classification, or superordinate category, was provided in approximately two thirds of all adequate definitions (see Table 7.5). However, a one-way related analysis of variance revealed that the inclusion of this information in definitions across the different categories differed significantly ($F(3, 20) = 6.835$, $p < 0.005$). Post-hoc Tukey tests revealed that significantly less of the furniture definitions contained the superordinate category than each of the three other categories at the 0.0005 level. In addition, the percentage of clothing definitions containing category information was significantly less than musical instruments, the category with the largest percentage of definitions containing category information, at the 0.05 level.

Clothing definitions also contained less major function information than the other types. Whilst an overall analysis of variance showed no significant difference, due to the similarity between furniture, vehicles and instruments on this measure, mean comparisons revealed that the clothing definitions contained significantly less major function information than both furniture and vehicles at the 0.05 level.

Type	total defns.	good synonym	major use	primary feature	category	minor use	secondary feature
F	136	12 (1)	120 (1.2)	254 (1.9)	52 (1)	7 (1.2)	167(1.7)
V	96	2 (1)	87 (1.3)	162 (1.7)	88 (1.06)	2 (1)	99 (1.6)
C	92	-----	44 (1.07)	204 (2.29)	61 (1.03)	1 (1)	81 (1.4)
I	67	1 (1)	53 (1)	190 (2.87)	59 (1)	-----	82 (1.5)
Total	391	15 (1)	304 (1.2)	810 (2.08)	260 (1.03)	10 (1.13)	429(1.6)

Table 7.6. Total number of instances of each element for each category. Mean number occurrences per containing definition in parentheses.

Key: F = furniture V = vehicles C = clothing I = musical instruments

In terms of the occurrence of components of definitions by category, a one-way related analysis of variance revealed that all were fairly evenly distributed except for primary features ($F(3, 20) = 5.930$, $p < 0.005$; see Table 7.6). Post-hoc Tukey tests showed that definitions of instruments contained significantly more primary features than both furniture and vehicles at the 0.0005 level and than clothing at the 0.05 level. In addition, clothing definitions contained significantly more instances of primary features than both vehicles ($p < 0.005$) and furniture ($p < 0.05$).

To summarise there were differences between word types in how well they were defined, such that atypical words were defined better than typical ones. In addition, definitions of low frequency words contained more primary distinguishing features than definitions of high frequency words. There were also differences among the definitions between the categories the targets were drawn from, with items of furniture being best defined and musical instruments worst. In terms of defining elements definitions of items of furniture contained less superordinate category terms than the other three categories. Musical instrument definitions contained most instances of category terms and clothing significantly less than these. Definitions of items of clothing also contained less functional information than items from the other three categories. In terms of primary features, musical instrument definitions contained more instances than items from the three other categories. Clothing definitions contained higher numbers of primary features than either vehicle or furniture definitions, both of which contained similar numbers.

These findings suggest that total score on the definition task is insufficient for assessing the semantic information available to a person about a target item. Variations between types of words, in terms of frequency and typicality, and between categories of words mean that the actual content of each definition must be examined. It is not possible to say that adequate definitions contain any particular combinations of features. The makeup of adequate definitions differs between semantic categories and between typical and atypical words and between high and low frequency words.

7.3 Experiment 7 - PRAD definitions

7.3.1 Introduction

Producing adequate definitions requires metalinguistic skills. There is evidence that PRAD patients have difficulty with at least some tasks reliant on metalinguistic skills. For example there is evidence of impaired speech error monitoring and repair in PRAD relative to controls (McNamara et al., 1992). There is further evidence in the finding that PRAD participants are worse than controls at correcting semantically, syntactically and phonologically incorrect sentences (Bayles, 1982). This finding though is less reliable as another study reports successful detection of most errors by both PRAD and controls (Kempler et al., 1987). Finally the evidence of reduced performance on verbal fluency tasks indicates a reduction in metalinguistic skills, specifically decreased ability to retrieve and organise information (see Experiment 3; also Diesfeldt, 1985; Hodges et al., 1992; Miller & Hague, 1975; Stuss & Benson, 1986).

In this experiment, PRAD participants provided definitions of the 24 target words used also in Experiments 3, 4, 5 and 6. These definitions were then rated by a group of independent raters for their adequacy. This rating task provides an objective measure of the definitions. In addition, I compare the definitions rated here with the key elements of adequate definitions identified in Experiment 6, to explore their occurrence. This adds to the picture of breakdown in available concept information in the PRAD participants. In addition this task provides a measure of the status of metalinguistic skills in PRAD. As such I expect the PRAD participants to produce fewer adequate definitions than age-matched controls due to their reduced metalinguistic ability. For this reason I also predict that they will provide fewer pieces of relevant information in their definitions due to the predicted reduced ability to recognise the requirements of providing conventional definitions.

7.3.2 Method

Subjects Nine individuals with PRAD, S1, S2, S3, S4, S5, S6, S7, S10 and S11 took part. They are one male and eight females aged between 75:0 and 85:8, with a mean age of 78:8 years (Appendix I). Their MMSE scores ranged between 7 and 22 with a mean of 14.6. Three female control participants (C1, C2, and C3) aged between 76:11 and 80:9 also took part. Their MMSE scores ranged between 27 and 30 with a mean of 29 (Appendix II).

Materials The 24 items used in Experiments 3, 4, 5 and 6 were arranged on a response sheet.

Procedure Participants were told that they would hear a word that they were to define. They should describe the word in such a way that someone who had never seen the item before would know what it was from their description. Words were presented verbally, one at a time, with participants allowed as much time as they required to provide their definitions. In a separate study a group of blind raters scored the definitions. In addition, the most typical features associated with individual items from the results of Experiment 6 provide a measure against which to evaluating the PRAD definitions.

7.3.3 Rating task

Method

Subjects There were 16 participants aged between 18 and 36 years, with a mean age of 20 years. Their years of formal education ranged between 13 and 20, with a mean of 15 years. Participants were recruited from the Psychology department subject pool, and through posters around the department. Each participant received £1.50.

Materials These comprised 12 sets of definitions for the 24 words used in Experiments 3, 4, 5 and 6. Nine were those of PRAD participants and three of age-matched controls. Some definitions contained the target words and these were omitted and replaced with (...). Two booklets were made each containing six sets of definitions. In addition, half of each booklet type contained a seventh set of definitions that were the materials produced for use in Experiment 5. Each booklet was put in a different order to randomize presentation of the sets of definitions. Following each definition there was a five-point rating scale for scoring. The front sheet of the booklet contained instructions on how to rate the definitions and examples of definitions worthy of each score. The front sheet also contained the 24 target words. The instructions were the same as those used for rating the definitions in Experiment 6.

Procedure. The two booklets were alternately distributed among the subjects, so that each was given to eight raters. Subjects were instructed to take as long as they liked to rate the definitions. They were to read each one in turn and then to turn to the front sheet to locate the target. They were then to use their judgement as to which score the definition merited. In this experiment and in Experiment 6, total scores are scaled down to give a score out of 24 for ease of comparison with scores in Experiments 4 and 5.

7.3.4 Results

The mean ratings for each item and then for each subject were calculated. The total adequacy rating for each set of definitions is displayed in Figure 7.2, where 24 would indicate perfect scores for each definition. Sets 1-9 are the PRAD definitions, 10, 11 and 12 the elderly controls and 13 the materials from Experiment 5. The experimental definitions from Experiment 5, whilst not receiving perfect ratings, did receive the highest scores of the 13 sets. The inclusion of these materials was to gain a measure of their adequacy at defining the target items and their total score suggests that they were adequate for this purpose. They are not analysed further. The three control sets of definitions are all rated significantly higher than any of the PRAD sets (Mann-Whitney U = 0.000, $p < 0.05$, control mean 20.02, PRAD group mean = 10.35).

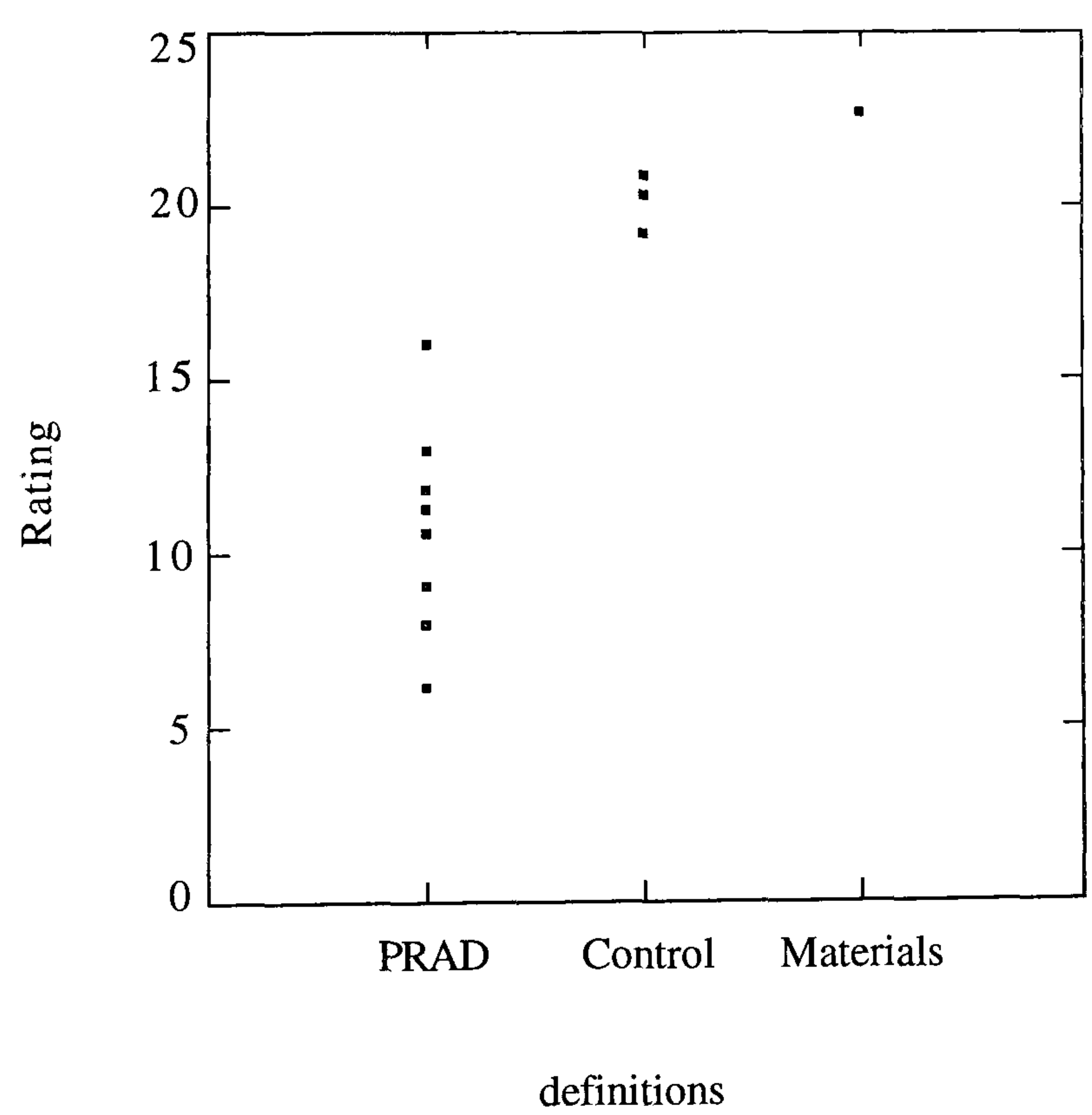


Figure 7.2. Total ratings for each set of definitions where 24 is maximum possible.

Looking at the ratings of each individual set of definitions the majority of PRAD definitions, 193 out of 216 (89%), received ratings above 0.5, indicating that they contained some relevant information. Only 23 of the PRAD definitions received ratings of less than 0.5 (see Appendix XIX). Six of the PRAD subjects provided at least one definition scored adequate (3.5 or above). In total PRAD participants produced 19 adequate definitions (see Table 7.7). None of the elderly control definitions received ratings below 0.5 although one definition did receive 0.5. Two thirds of the elderly control definitions received ratings of 3.5 or above. This is substantially higher than the 43% of young adults' definitions rated adequate in Experiment 6. Whilst the PRAD participants are clearly worse at producing adequate definitions to the words than the elderly controls, this does not seem to arise from a failure to recognise the majority of items. This is supported by the finding that just under 90% of PRAD responses contained some relevant information about the target word.

Participants	S1	S2	S3	S4	S5	S6	S7	S10	S11	total
max	2	6	4	2	0	0	0	1	4	19
min	21	23	23	23	20	22	18	21	22	193

Table 7.7. Numbers of PRAD definitions rated adequate and those containing some relevant information.

Max = number of definitions rated adequate (3.5 or above)
Min = number of definitions providing at least minimal information (0.5 - 4).

To determine the explanation for the poorer scoring of the PRAD participants, I examined the definitions for the components identified in the definitions produced by healthy young adults described in Experiment 6. First considered are the 23 definitions rated at 0.5 or less Of these, three are "don't knows", one a no response and eight contain wholly irrelevant information. Among the remaining twelve are one instance of a major usage (*dress* defined simply as "wear"), two instances of an item's category ("mechanical instrument" for *rocket*, "instrument" for *violin*) and one of minor usage ("if you're out hunting" for *cap*). Seven of the twelve definitions contain secondary features and four contain the target word. None of these inadequate definitions contain examples of good synonyms or primary (defining) feature(s) whereas in Experiment 6, 97% of definitions receiving adequate ratings of 3.5 or greater contain primary features.

The 19 PRAD definitions rated adequate (3.5 or above) contain significantly more components, that is pieces of relevant information, than the definitions of the same items with ratings below 3.5 (mean number of pieces of information for adequate definitions = 3.09, mean for inadequate definitions = 1.918, $t(9) = 4.59$, $p < 0.001$). Thus 89% of PRAD definitions contain relevant information but in 80% there is insufficient to adequately define the targets. This difference also occurs in the elderly controls' definitions, where the mean number of pieces of relevant information contained in definitions rated adequate was 3.86 and in the inadequate definitions was 2.93 ($t(13)$ 3.484, $p < 0.005$). Interestingly, the mean number of pieces of information in the adequate PRAD definitions (3.09) is less than the mean in both the adequate definitions of the elderly controls (3.86) and the healthy young adults' in Experiment 6 (4.68).

In addition to the *amount* of information contained in the definitions is the *type* of information. The results of Experiment 6 reveal that there is no formula for producing adequate definitions. In other words, it is not possible to say that if a definition contains, for example, an instance of major usage, a primary feature and the target's category, that it will always be satisfactory. The analysis in Experiment 6 reveals first, that the production of adequate definitions is not equal across the different word types (high frequency typical, low frequency typical, high frequency atypical and low frequency atypical). Second, that there are differences in the numbers of components included in definitions for the different word types. Third, that there is a difference in the numbers of adequate definitions produced to the different categories of words (furniture, vehicles, clothing and musical instruments). Fourth, that the distribution of definition components

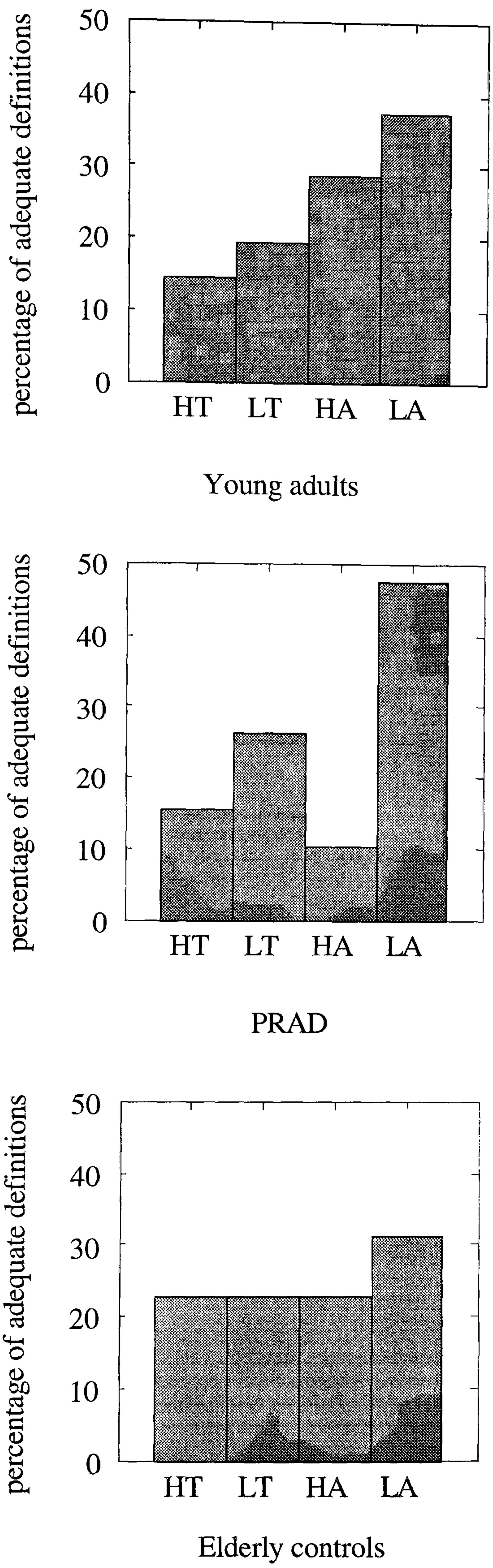


Figure 7.3 . Comparison of adequate definitions made to the four word types by the young adults (Experiment 6; n = 391), the PRAD (n = 19) and the elderly control (n = 48) participants.

Key: HT= high typical; LT = low typical; HA = high atypical; LA = low atypical.

is not even across the four categories. These four differences are explored in turn in the PRAD and control data and comparisons made with the findings in Experiment 6. In addition differences between the adequate and the relevant but inadequate definitions are explored.

Word types. In Experiment 6 the distribution of adequate definitions differs across the four word types (see Figure 7.3). The distribution of adequate definitions made by the PRAD participants also differ across word types but not in the same way as found in Experiment 6. Among the PRAD adequately rated definitions least were made to high frequency atypical words, compared with least to high frequency typical words by the young adults in Experiment 6. The distribution of adequate definitions made by the elderly controls is different again both to the pattern found in Experiment 6 and to that of the PRAD group. However, in all three groups of adequate definitions the largest proportion are to low frequency atypical words (see Figure 7.3).

To examine underlying concept knowledge and the participants' abilities to meet the requirements of providing conventional definitions the PRAD and elderly control definitions were examined for the six constituent elements of definitions identified in Experiment 6. Three additional categories were added in this experiment to enable comparisons between the adequate and inadequate (ratings between 0.5 and 3.49) definitions. These are definitions containing the target word, the inclusion of irrelevant information (e.g. "a necessity these days" for *car*) and redundant or misleading information (e.g. "has a headboard" for *sofa*).

The first comparison is with the occurrence of components found in Experiment 6. Taking each component in turn comparison of the five sets of results reveals some interesting findings. The number of synonyms in the PRAD adequate definitions far exceeds those found in any of the other four groups (see Table 7.8). Both PRAD and control adequate definitions contain more instances of major usage than their respective inadequate definitions. Neither of these, though, are as high as the instances among young adults' definitions. Similarly both the PRAD and control adequate definitions contain higher proportions of primary features than their respective inadequate

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad. n =12	21.05	52.6	89.8	42.1	5.26	27.7	0	5.26	0
P in n =174	4.02	36.2	47.1	31.6	7.47	30.5	5.17	9.77	8.04
C ad. n = 48	4.16	43.7	93.7	45.8	4.16	60.4	2.08	2.08	0
C in. n= 24	8.33	29.2	75	45.8	8.33	66.6	0	4.16	8.33
Exp 6 n = 391	3.9	67	97	65	2.3	70	0	0	0

Table 7.8. Percentages of PRAD adequate and inadequate, control adequate and inadequate and young adults' adequate definitions containing each component across all word types.

P ad = PRAD adequate; P in = PRAD inadequate; C ad = Control adequate; C in - Control inadequate; Exp 6 = Experiment 6 (young adults).

Syn = good synonym; Maj = major function; Prim = primary feature(s); Class = category; Min = minor function(s); Sec = secondary feature(s); Targ = includes target word; Irrel = irrelevant information; Red = redundant or misleading information.

definitions. Again the highest percentage is in the young adults' definitions as is the highest percentage of definitions containing category information. PRAD adequate definitions contain more category information than PRAD inadequate whilst both sets of control definitions contain the same percentage of category information. On minor functions both sets of inadequate definitions contain more than their respective adequate definitions. On this component the young adults' definitions contain the smallest percentage. The largest percentage of definitions containing secondary features are those of the young adults. However, both PRAD and control adequate definitions contain less secondary features than their respective inadequate definitions. None of the PRAD adequate definitions contain the target word whilst 5% of their inadequate ones do. Conversely, none of the control inadequate definitions contain the target word but 2% of

Tables 7.9a, b, c, d. Mean occurrence of components in PRAD adequate and inadequate definitions, control adequate and inadequate definitions and young adults' definitions (Experiment 6) of different word types.

(a) high frequency typical

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad n = 3	0	1	1	0	0	1	0	0	0
P in n = 46	1	1	1.46	1	1.5	1.41	1.5	1	1
C ad n = 11	0	1	2.1	1	0	1	0	0	0
C in n = 7	0	1	1	1	1	1	0	1	0
Exp 6 n = 57	1	1.4	1.7	1	1	1.8	0	0	0

(b) low frequency typical

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad. n = 5	1	1	1	1	0	0	0	0	0
P in n = 46	1	1	1	1	1	1	1	1	1
C ad. n = 11	1	1	1.9	1	0	1.16	0	0	0
C in n= 7	0	1	1.4	1	0	1.4	0	0	2
Exp 6 n = 76	1	1	2.4	1	1.5	1.8	0	0	0

(c) high frequency atypical

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad. n =2	0	1	1.5	1	0	2	0	0	0
P in. n =42	1	1.21	1.08	1	1.3	1.1	1	1	1
C ad. n = 11	1	1.42	1.6	1	1	1.14	1	0	0
C in. n= 7	1	1	1.3	1	1	2	0	0	0
Exp 6 n = 112	1	1.3	1.9	1.1	1	1.5	0	0	0

(d) low frequency atypical

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad. n = 9	0	1	1.55	1	0	1.75	0	1	0
P in n = 40	0	1	1.22	1	1	1.05	0	1	1.25
C ad. n = 15	0	1	2.06	1	1	1.75	0	1	0
C in. n = 3	0	0	1.5	1	0	1.66	0	0	1
Exp 6 n = 146	0	1	2.3	1	1	1.4	0	0	0

their adequate ones do. Both PRAD and control inadequate definitions contain more irrelevant information than their respective adequate definitions. Similarly both sets of inadequate definitions contain redundant and misleading information, whilst neither the PRAD nor control adequate definitions contain any of this. Across all five sets of definitions there are no instances of synonyms in definitions of LA words (see Table 7.9d). Young adults give more instances of major usage in definitions of high frequency words than low. This is only true of the control adequate definitions (Tables 7.9a & c) and the PRAD inadequate definitions of high frequency atypical words (see Table 7.9c). On all word types the control adequate definitions contain more primary features on average than the inadequate definitions. This is only so for the PRAD definitions of atypical words (Tables 7.9c & d). PRAD inadequate definitions contain more minor functions for each word type than the PRAD adequate definitions. This consistency is not found in the control definitions. There are no obvious patterns in any of the sets of definitions for the provision of secondary features.

The most obvious differences appear on the occurrences of (i) the target word in definitions, (ii) irrelevant information and (iii) redundant or misleading information. On all of these, with the exception of low frequency atypical words where there is some irrelevant information, the PRAD inadequate definitions contain instances whereas the adequate ones do not. Where these components do occur among the control definitions, there are more in the inadequate definitions.

For the PRAD definitions at least, it appears that the reason for definitions receiving inadequate ratings is that they contain the target word or irrelevant or misleading information. As these definitions contain significantly less information than the adequate ones anyway, the provision of irrelevant or misleading information is clearly a factor in why the definitions are inadequate. Among the control definitions the major difference between those rated adequate and those inadequate appears to be the amount of primary, defining, features provided.

	L-H	A-T
PRAD adequate	0.43	0.082
PRAD inadequate	0.133	0.101
Control adequate	0.15	-0.116
Control inadequate	0.156	0.07

Table 7.10 Mean differences in occurrence of primary features between high (H) and low (L) frequency words and typical (T) and atypical (A) words for the PRAD and elderly control adequate and inadequate definitions.

Experiment 6 the definitions of low-frequency words contained significantly more instances of primary features than those of high-frequency words. This does not seem to occur in the definitions made by both the PRAD participants and the elderly controls as indicated by comparison of the mean occurrence of primary features in the high- and low-frequency word definitions made in this study (see Table 7.10). Similarly there does not appear to be a difference in the mean occurrence of primary features between the definitions of typical and atypical words (see Table 7.10).

Categories. In Experiment 6 the young adults produce different numbers of adequate In definitions to the different categories. Most are made to items of furniture and least to musical instruments. The distribution of adequate definitions made by the PRAD and elderly controls show this same pattern. Indeed, the PRAD participants made no adequate definitions of musical instruments (see Figure 7.4). The distribution of adequate definitions made by the elderly controls follows the same pattern to that of the young adults with slightly more to vehicles than clothing.

In terms of the occurrence of components, in Experiment 6 no definitions of clothing contain synonyms. This was also the case for both the adequate and inadequate control definitions for items of clothing (see Table 7.11c). However both sets of PRAD clothing definitions contain examples of synonyms. In production of instances of major usage the elderly control adequate definitions most closely resembled those of the young adults across all categories. In Experiment 6 definitions of musical instruments contained significantly more instances of primary features than any of the other categories. As there are no PRAD adequate definitions of musical instruments this comparison can not

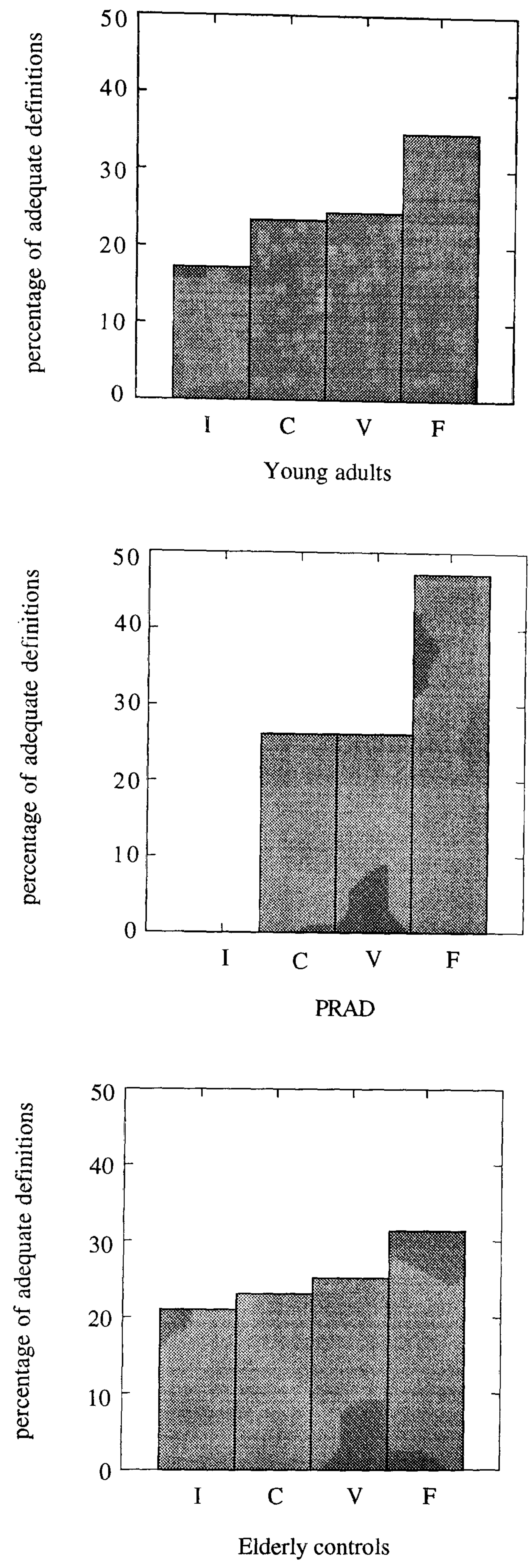


Figure 7.4. Comparison of the distribution of adequate definitions made to the four categories by the young adults (n = 391; Experiment 6), the PRAD (n = 19) and the elderly control (n = 48) participants.

Key: HT= high typical; LT = low typical; HA = high atypical; LA = low atypical.

Tables 7.11a, b, c, d. Mean occurrence of components in PRAD adequate and inadequate definitions, control adequate and inadequate definitions and young adults' definitions (Experiment 6) of items from different categories containing them.

(a) Furniture

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad n = 9	1	1	1.6	1	1	1.6	0	1	0
P in n = 41	1	1	1.05	1	1	1.27	1	1	1
C ad n = 15	1	1.3	1.6	1	0	1.5	1	0	0
C in n = 3	0	1	1	0	0	2	0	0	2
Exp 6 n = 136	1	1.2	1.9	1	1.2	1.7	0	0	0

(b) Vehicles

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad. n = 5	0	1	1	1	0	1	0	0	0
P in n = 43	1	1.12	1.15	1	1.3	1.41	1	1	1
C ad. n = 12	0	1.3	1.25	1.2	1	1.4	0	0	0
C in n= 6	0	1	1.2	1	0	1.25	0	1	0
Exp 6 n = 96	1	1.3	1.7	1.06	1	1.6	0	0	0

(c) Clothing

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad. n =5	1	1	2.2	1	0	1	0	0	0
P in n = 44	1	1	1.21	1	1	1	2	1	1
C ad. n = 11	0	1	2.45	1	0	1.28	0	1	0
C in n=7	0	1	1	1	1	2.16	0	0	0
Exp 6n = 92	0	1.07	2.29	1.03	1	1.4	0	0	0

(d) Instruments

Component	Syn	Maj	Prim	Class	Min	Sec	Targ	Irrel	Red
P ad.n = 0									
P in n = 46	1	1	1.13	1	1	1.17	1	1	1.28
C ad. n = 10	1	1	2.8	1.2	1	1	0	0	0
C in n = 8	1	0	1.5	1	0	1.8	0	0	1
Exp 6 n = 67	1	1	2.87	1	0	1.5	0	0	0

be made. However, among the three categories to which there are adequate definitions, the lowest number of primary features are in the vehicle definitions. This is the same as the young and elderly controls. In the elderly control adequate definitions instruments had the highest mean number of primary features per definition (2.8) and vehicles the lowest (1.25). All of the adequate definitions contain at least one instance of major classification across all categories of items. Provision of secondary usage is more randomly distributed across the five sets of definitions. Secondary features are found in all sets of definitions across all categories. In furniture definitions, PRAD adequate definitions contain more of these than the inadequate, whereas in vehicle definitions the inadequate contain more on average and in clothing they were the same. Among control definitions, in all but vehicles the inadequate contain more instances of secondary features on average than the adequate.

To summarise the PRAD participants produced fewer adequate definitions than either the elderly or the young controls. However, 89% of their definitions contained some relevant information. In addition, like the other two groups of participants, the PRAD group produced most adequate definitions to low frequency atypical words. Overall PRAD definitions contained fewer pieces of information than definitions produced by the other two groups. The PRAD group's definitions also contained fewer of the important components of definitions, that is primary features, major use and category.

7.3.5 Discussion

Providing adequate definitions is a difficult task. The highest rated set was the materials from Experiment 5 and these did not receive perfect scores. PRAD participants made very few definitions that received adequate ratings and their performance was significantly worse than that of the age-matched controls. In addition, the number of adequate definitions made by the controls exceeded that made by the young adults in Experiment 6.

All of the PRAD definitions contained reduced information compared to both control groups. The mean number of information components in the adequate definitions was lower than that of both the controls and the young adults. In addition, PRAD definitions rated as inadequate contained significantly fewer pieces of information than those rated as adequate. This is one reason why so few of the PRAD group's definitions were rated adequate.

A second factor lies in the information contained in the definitions. By far the majority of PRAD definitions contained relevant information. However, in the inadequate definitions this was more likely to be secondary functions and characteristics, rather than primary ones. PRAD inadequate definitions also contained more instances of the target word and irrelevant and misleading or redundant information. Definitions in Experiment 6 also contained larger amounts of secondary features than the PRAD and control adequate definitions. However, the mean number of pieces of information was the highest for these definitions. Thus the provision of secondary features was *as well as* primary functions and characteristics. In the PRAD inadequate definitions it tended to be *instead of* primary information. In other words the PRAD inadequate definitions contain less information and what information they do contain is not the more important items such as primary features and major usage.

The finding that 97% of definitions in Experiment 6 contain primary features supports the importance of primary information. The majority of definitions also contain at least one example of a major function and the major classification that the item belongs to. In addition, the major difference between the control adequate and inadequate definitions appears to be the higher average occurrence of primary features in the former.

It has been suggested that provision of the superordinate category label by PRAD patients indicates the loss of specific item knowledge in the face of preserved category-knowledge (Flicker et al., 1987; Hodges et al., 1991; Martin & Fedio, 1983). However, in the scoring criteria of the WAIS-R vocabulary scale, for some of the early concrete nouns, classification of the item is sufficient for an adequate rating. This suggests that identifying the category is an important part of providing a noun definition. This is supported by the finding that the materials from Experiment 5, the highest rated definitions, all contain category information. One explanation for the difference in interpretation could arise from the tasks used. Most of the evidence for loss of item knowledge derives from naming studies. However, the evidence from this study is that PRAD patients' definitions do not generally include as much classificatory information as those of young adults. It should be noted, however, that less than half of the control adequate definitions contained category information. In addition, there does not appear to be a loss of individual item knowledge in the PRAD group.

As 90% of PRAD definitions contain some relevant information it seems that they do have information about the items but cannot meet the demands of the task by providing sufficient relevant information to adequately define the items. The failure of PRAD patients to provide adequate definitions seems to have more to do with the metalinguistic knowledge (Bialystok & Ryan, 1985) needed to monitor output and to keep in mind the demands of the task. It is claimed that children must have metalinguistic knowledge of what a definition is to enable them to produce adult-like, Aristotelian definitions (Watson, 1985; Wehren et al., 1981). The evidence from PRAD patients suggests that they lose the metalinguistic skills that regulate retrieval and organization of relevant material. This loss of skill also impairs their ability to understand the requirements of a formal definition and to monitor their output in this task.

7.4 General discussion

Experiments 3, 4, 5, and 7 were designed to investigate the hypotheses presented at the end of Chapter Four by probing the integrity of both semantic and lexical representations. If intact then two of the hypotheses, that loss or damage to either semantic or lexical units underlies the speech disorder in PRAD, can be ruled out.

One of the criteria for concluding a semantic storage disorder is that item-specific information will be lost in the face of preserved category information (Warrington & Shallice, 1979). In the two naming tasks the majority of semantic substitutes are co-ordinates rather than superordinates. Thus, these findings do not support an impaired semantic store account.

Another of the criteria suggested as indicating a storage disorder is that low frequency items will be lost before higher frequency ones (Warrington & Shallice, 1979). This is based on the assumption that the former have smaller representations than the latter (Shallice, 1988). In the naming to definitions (TOT) task both high and low frequency words were the targets in TOT states. In addition, there were no frequency effects in any of the groups of nontarget responses. That is, where the target was not produced, there was no tendency to substitute with a higher frequency item. On the comprehension tasks there was also no tendency to select higher frequency distractors. There was an effect of typicality on failed targets, in that more atypical items were incorrect. However, more typical distracters were not selected. This also goes against the idea of loss of specific item knowledge in the face of preserved category knowledge.

Further evidence against loss of low frequency items, and thus against the impaired semantic store account, comes from comparing the findings of Experiment 5 (TOT) with the two definitions experiments (6 and 7). In Experiment 5 high frequency typical items were the most successfully named to definition of the four word types by the PRAD participants. Low frequency, atypical items were responded to worst of the four. In Experiment 7 low frequency atypical items were adequately defined more often than any of the other word types by the PRAD participants. This was so for the age-matched controls and also the young adults in Experiment 6 as well. In addition, in Experiment 6, the worst defined words were high frequency typical. These findings together do not support the hypothesis that low frequency, less familiar items are lost whilst high frequency typical items are preserved.

Additionally, the evidence from category fluency suggests that the poorer performance of PRAD participants does not stem from a loss of atypical items. The time allowed for generating category members was longer than is usual and under these conditions, the PRAD participants showed similar patterns of item generation to elderly controls and young adults. The reduced generation of the PRAD group seems to reflect processing difficulties in meeting the task requirements.

Returning to my four hypotheses, the findings suggest that there is no loss of items, either at the semantic or lexical level of representation. Distinguishing between the other two hypotheses is more difficult. However, there is evidence which suggests that disinhibition of within-level lexical connections cannot account for semantic word substitutions (Harley & MacAndrew, 1992). In simulations of this interactive activation two-stage model of lexicalization, decreasing within-level lexical inhibition did not result in output of semantic relatives.

This leaves one hypothesis, that of impaired links between semantic and lexical representations. This was also considered the most likely explanation of word substitutions in aphasic speech (Harley & MacAndrew, 1992). With this explanation, there would be no prediction of frequency effects in substitutions. This is because if activation does not pass to the target lexical item it will pass to a close semantic relative. That is, an item with a very similar semantic specification, which may or may not be higher in frequency. The semantic similarity alone will guide substitute selection.

The high number of definitions containing some information and high levels of comprehension performance suggest that *input* connections between lexical and semantic items are intact. The lower level of production on category fluency supports the notion of a problem retrieving lexical items for output. This hypothesis is the equivalent, with a two-stage model, of the impaired Warrington and Shallice (1979) access account of semantic impairment. Thus semantic, and lexical, representations are intact, but there is a problem translating between them.

While the data offer support for one hypothesis over the other three, one final point must be made. This is that in several of the tasks, reduced performance may be attributable, at least in part, to a reduced ability to meet the task requirements. To evaluate the contribution of this factor, it is necessary to examine individual performance profiles. By looking across tasks, individual task difficulty can be assessed. Bayles et al. (1991) proposed that response profiles in PRAD reflect task-specific impairment rather than item-specific semantic loss. By examining performance across tasks both of these accounts can be evaluated.

If there is an item-specific loss then responses to individual items should be consistent across tasks. If there is task-specific impairment, response patterns may be inconsistent. Participants making inconsistent responses would be predicted to make correct responses to easy tasks and incorrect to more difficult ones. Response profiles for six PRAD participants are examined in Chapter 8.

Chapter 8

Response consistency in six cases

8.1 Introduction

Analysis of PRAD performance on each of Experiments 3, 4, 5 and 7, offers support for the hypothesis that disordered speech results from weakened connections between intact semantic and lexical representations. This hypothesis is further explored in this chapter, through examining the performance of the six PRAD participants who each did every task in Experiments 3, 4, 5 and 7. Analysis of their performance with each item on each task provides critical data for addressing the consistency question.

Response consistency is considered by Shallice (1988) one of the two most reliable criteria for identifying a semantic storage disorder, although this has been questioned (Caplan, 1992; Faglioni & Botti, 1993). At the end of Chapter 6, I concluded that the data do not support two of the other criteria - loss of lower frequency items before higher and depth of processing (subordinate items lost before superordinates). However, examining response consistency is useful for two reasons. One is to evaluate further the item-specific, semantic impairment account. The other is to explore the idea of task-specific impairment. This is suggested by some of the findings in Chapters 5 and 6, where poor PRAD performance appears to result from impaired ability to meet specific task requirements.

8.2 Consistency

Consistency in responding to a given item is commonly employed as a tool for examining semantic memory impairment in PRAD. There are three methods for collecting these data. One is repeated administrations of the same task. The second is through multiple tasks with the same stimuli. The third combines the other two with repeated administration of a battery of tasks (e.g. Bayles et al., 1991). Using this latter method, Bayles et al. (1991) found task-specific rather than item-specific loss. They explain their data in terms of an impairment of task performance in PRAD. With reference to the semantic impairment account they urge caution in the interpretation of consistency data for five reasons. First, that there is a variation between tasks in how much, if at all, they use semantic memory. Second, that multiple choice tasks offer a high chance level of success (depending on the number of choices). Third, that tasks vary in difficulty with generative tasks more difficult than comprehension tasks. Fourth, the frequency and familiarity of items vary and what is interpreted as "item lost" may actually be "item never known". Fifth is the relationship between severity level and performance. They suggest that participants who fail to respond correctly to some items across all tasks could, given an additional task that calls on semantic memory but is easier than the other tasks used, still respond correctly.

Examination of the findings so far in this thesis offers some support for an impairment in task performance rather than semantic information. To explore this further through response consistency, I now consider data from six of the PRAD participants who took part in each of Experiments 3 - 6.

8.3 The participants

S1, S2, S3, S4, S5 and S6 all completed these tasks, as described in Chapters 5 and 6. They are all female, with ages ranging between 72:2 and 85:8 years (mean age 81:11). The tasks were administered over several sessions. Owing to problems keeping in contact with all of the participants the time between sessions was not consistent. However, as far as possible the tasks were administered in the same order to each participant. This was category fluency first, then producing definitions, naming to definition, picture naming, between-category comprehension and within-category comprehension.

8.4 Results

With the exception of the verbal fluency task where there is no upper limit, the total score possible for each participant on each task is 24. The total scores achieved suggest that the tasks are not of equal difficulty, with comprehension tasks easier (Table 8.1).

	verbal fluency	naming	between category	within category	TOT	defining
S1	17	15	23	23	16	2
S2	17	19	23	23	21	6
S3	7	10	14	15	7	4
S4	23	15	24	21	15	2
S5	35	17	22	23	8	0
S6	19	13	24	22	13	0
Total	118	89	130	127	80	14

Table 8.1 Total score achieved on each task by each participant

Performance on both within- and between-category picture matching was significantly better than picture naming, naming to definition and providing definitions (Table 8.2). Performances at picture naming and naming-to-definition are similar. Providing unequivocal definitions is the most difficult task of all. This is confirmed by comparison with the performance of healthy adults on the same task (Experiment 6). A rating of 16 was the highest achieved by one of this group of six PRAD participants, where 24 would be perfect. The mean rating for definitions of the 24 items produced by a group of 38 undergraduates was 19.6 (Experiment 6).

	between category	within category	TOT	defining
naming	0.002	0.005	N.S.	0.0005
between category		N.S.	0.0005	0.0005
within category			0.001	0.0005
TOT				0.0005

Table 8.2 Significance levels of differences in task performance

The crucial question here is: are the same items correct in each task? That is, are the same people correctly naming and defining items that they have comprehended? Or put another way, is the single definition of "barge", for instance, produced by a participant who also correctly responded to this item on the other tasks? (see Table 8.3) Whilst this question is quite straight forward, finding the answer is not. Bayles et al. (1991) analyzed performance on each item by each subject across all tasks using loglinear analysis. For this all possible permutations of response patterns to each item across tasks must be identified. The frequency count of each possible permutation is then calculated. For two tasks there are four possible permutations, for three tasks eight, for four tasks sixteen and for five tasks 32 for each item. Unfortunately I did not have access to a statistical package that could carry out this calculation. I have therefore used an alternative method to answer this question.

Instead, I examine the conditional probability of defining an item given that it is successfully responded to in all the other tasks. This probability is compared with the frequency of items correctly defined divided by the number possible. This shows if the items correctly defined are also correct on other tasks. A significant *t* value shows that they are the same. The reason for taking defining as the critical task is that it is arguably the most difficult task, with fewest items correct. If failure to respond correctly arises

	naming	CB	CW	TOT	Def.
barge	2	6	5	3	1
trumpet	3	6	5	3	0
shirt	6	6	5	4	0
bath	3	5	6	4	0
tambourine	3	6	6	1	0
van	0	5	5	0	0
cap	4	6	6	5	1
chair	6	5	6	5	0
violin	5	6	6	6	0
apron	4	6	6	3	1
curtains	6	5	6	4	1
car	6	6	6	3	0
wardrobe	5	5	5	5	2
turban	3	5	4	3	1
piano	6	6	6	6	0
rocket	0	5	5	0	0
castanets	0	4	2	1	0
coach	4	6	4	3	0
dress	6	6	6	3	0
sofa	5	5	6	6	1
trousers	6	6	6	3	1
train	6	5	5	6	2
recorder	0	5	5	1	0
hammock	1	4	5	2	3
total	90	130	127	80	14

Table 8.3. Number of participants (n = 6) correctly responding to each item on picture naming, between-category picture-word matching, within-category picture-word matching, naming to definitions and providing definitions.

from loss of item knowledge, then it should not be possible to adequately define items that are not correct on easier tasks. Comparison of the two sets of probabilities is not significant ($t(23) = 0.33$, $p > 0.7$) which indicates that the items defined correctly are not the same items that are correct in all other tasks. That is, ability to adequately define an item is independent of success on other tasks.

This analysis essentially answers the question of whether responding is consistent. Demonstrating that some items that are correctly defined are not correctly responded to on all of the other tasks illustrates inconsistent responding. It could be argued that success with an item on any task is sufficient to conclude that an item is not lost. If this success occurs only on one of the comprehension tasks, though, then this conclusion must be drawn cautiously. This is because, with a four picture forced-choice task, the chance level of success is 0.25. However, the chance level of successfully identifying an item on both tasks is 0.062. A comparison of the items correct on the two comprehension tasks shows that performance on them is not independent ($t(23) = 2.482$, $p < 0.05$). That is, the same items are correct, or incorrect, on both tasks.

A similar comparison of the two naming tasks, however, shows that different items are correctly identified in each ($t(23) = 0.87$, $p > 0.35$). In addition, paired comparisons of the items correct on the two naming and two comprehension tasks reveal further inconsistencies. Items were not responded to in the same way on picture naming and between-category comprehension ($t(23) = 1.69$, $p > 0.05$). However, similar responses were made in picture naming and within-category comprehension ($t(23) = 2.43$, $p < 0.05$). Items named to definition were not necessarily correct on either between-category comprehension ($t(23) = 1.19$, $p > 0.2$) or within-category comprehension ($t(23) = 0.46$, $p > 0.6$). These findings are important for examining the question of response consistency. It is on the lower-scoring, generation tasks that 'lost' items should be most obvious. Thus if a semantic storage impairment is the cause of failure to name a picture, it should not be possible to name the same item in response to a definition. Thus far the patterns of responding appear to be inconsistent, given the differences in relative difficulty of the tasks.

8.5 Individual cases

Performance of the six PRAD subjects is now analysed separately to explore consistency in responding across tasks.

8.5.1 Subject 1 - ZO

ZO performed well on the two comprehension tasks, less so on the two naming tasks, and

	naming	CB	CW	TOT	Def.
barge	0	1	1	1	0
trumpet	1	1	1	1	0
shirt	1	1	1	1	0
bath	0	1	1	1	0
tambourine	0	1	1	0	0
van	0	1	1	0	0
cap	1	1	1	1	0
chair	1	1	1	1	0
violin	1	1	1	1	0
apron	1	1	1	1	0
curtains	1	1	1	1	0
car	1	1	1	1	0
wardrobe	1	1	1	1	1
turban	0	1	1	1	0
piano	1	1	1	1	0
rocket	0	1	1	0	0
castanets	0	0	0	0	0
coach	1	1	1	0	0
dress	1	1	1	0	0
sofa	1	1	1	1	1
trousers	1	1	1	1	0
train	1	1	1	1	0
recorder	0	1	1	0	0
hammock	0	1	1	0	0
total	15	23	23	16	2

Table 8.4. Response profile of participant ZO on the five tasks scored out of 24.

worst of all at defining (Table 8.5). Her performance on the naming tasks shows inconsistencies. She correctly named two items to picture stimuli but not to their definitions. ZO also named three items to their definitions that she did not name to their pictures. One item, *castanets*, was not responded to correctly on any of the tasks. This can be interpreted as a lost item. However, as a low frequency, atypical item, it may never have been known. Alternatively, if there is an access problem and responding is random it is possible that some items in storage will never be accessed on any of the tasks.

8.5.2 Subject 2 - GI

	naming	CB	CW	TOT	Def.
barge	1	1	1	1	0
trumpet	1	1	1	1	0
shirt	1	1	1	1	0
bath	1	1	1	1	0
tambourine	1	1	1	1	0
van	0	1	1	0	0
cap	1	1	1	1	1
chair	1	1	1	1	0
violin	1	1	1	1	0
apron	1	1	1	1	1
curtains	1	1	1	1	1
car	1	1	1	1	0
wardrobe	1	1	1	1	0
turban	1	1	1	0	0
piano	1	1	1	1	0
rocket	0	1	1	0	0
castanets	0	0	0	1	0
coach	1	1	1	1	0
dress	1	1	1	1	0
sofa	1	1	1	1	0
trousers	1	1	1	1	1
train	1	1	1	1	1
recorder	0	1	1	1	0
hammock	0	1	1	1	1
total	19	23	23	21	6

Table 8.5. Response profile of participant GI on the five tasks scored out of 24.

GI made the most correct responses of the six participants. However, her profile also contains instances of inconsistent responding (Table 8.5). One item, *castanets*, was correctly named to the definition but not on any other task. As explained above, this is a low frequency atypical item. That it was correct on a production task suggests that the item was known and provides support for an access disorder, rather than a storage impairment. In addition, three items were named to definition that were not named to their pictures. One further item was named to the picture but not the definition. Four of the six items adequately defined were also correct on all other tasks. The other two were correct on all tasks but picture naming. All of these inconsistencies go against the impaired storage account.

8.5.3 Subject 3 - LJ

	naming	CB	CW	TOT	Def
barge	1	1	1	1	1
trumpet	0	1	0	0	0
shirt	1	1	0	0	0
bath	0	0	1	0	0
tambourine	1	1	1	0	0
van	0	0	0	0	0
cap	0	1	1	1	0
chair	1	0	1	0	0
violin	0	1	1	1	0
apron	0	1	1	0	0
curtains	1	0	1	0	0
car	1	1	1	0	0
wardrobe	0	0	0	0	1
turban	0	0	0	0	1
piano	1	1	1	1	0
rocket	0	1	0	0	0
castanets	0	1	1	0	0
coach	0	1	0	1	0
dress	1	1	1	0	0
sofa	1	0	1	1	0
trousers	1	1	1	0	0
train	1	0	0	1	0
recorder	0	0	1	0	0
hammock	0	0	0	0	1
total	11	14	15	7	4

Table 8.6. Response profile of participant LJ on the five tasks scored out of 24.

LJ has a particularly interesting profile. Of the six she scored lowest on the comprehension tasks, suggesting a greater degree of dementia severity (Table 8.6). This is confirmed by her MMSE score of 7 (see Appendix I). It is in patients showing greater deterioration that item loss should be most apparent. Indeed, in LJ's profile there is evidence to support the argument of item-specific loss. One item, *van*, was not correctly responded to on any task. Unlike *castanets,* which ZO failed to respond to correctly on any task, this is not an atypical item that may never have been known. In addition, two items, *trumpet* and *bath*, were each responded to correctly on only one comprehension task. This could be by chance.

However, the profile of LJ also shows many inconsistencies. Her picture naming and comprehension scores are not very different, unlike the other participants. As her comprehension scores are well below the level of the other participants, her naming scores would be predicted to decrease exponentially. This is especially so if output tasks are less resistant to storage impairment. One item, *train*, was correct on both naming tasks but neither comprehension task. More importantly, she adequately defined three items that she did not respond to correctly on any of the other, easier tasks. Also, her defining performance of four adequate definitions (16.6%), is higher than the other participants whose naming and comprehension performance suggest they are less deteriorated than LJ (ZO, DG, LO and LE). The overall pattern of inconsistencies suggest that items are not lost, but rather that LJ has difficulties in consistently manipulating information to meet the requirements of the tasks.

8.5.4 Subject 4 - DG

In DG's profile there are two instances of items only responded to correctly on a single comprehension task, offering support for the lost item account (Table 8.7). Additionally, and perhaps the most interesting feature of the profile, she responded correctly to the same amount of items on both naming tasks. However, they were different items correct on these two tasks. DG correctly named three items to their pictures but not their definitions. She also named three items to their definitions but not their pictures. One of the two items she adequately defined was not named to definition. An additional item, *wardrobe*, was correctly named to both picture and definition but only correct on one of the comprehension tasks. These inconsistencies go against the item-specific loss explanation.

	naming	CB	CW	TOT	Def.
barge	0	1	0	0	0
trumpet	0	1	1	1	0
shirt	1	1	1	1	0
bath	0	1	1	1	0
tambourine	1	1	1	0	0
van	0	1	1	0	0
cap	1	1	1	1	0
chair	1	1	1	1	0
violin	1	1	1	1	0
apron	1	1	1	1	0
curtains	1	1	1	1	0
car	1	1	1	1	0
wardrobe	1	1	1	1	0
turban	1	1	0	1	0
piano	1	1	1	1	0
rocket	0	1	1	0	0
castanets	0	1	0	0	0
coach	0	1	1	0	0
dress	1	1	1	1	0
sofa	0	1	1	1	0
trousers	1	1	1	0	0
train	1	1	1	1	1
recorder	0	1	1	0	0
hammock	1	1	1	0	1
total	15	24	21	15	2

Table 8.87 Response profile of participant DG on the five tasks scored out of 24.

8.5.5 Subject 5 - LO

Participant LO also has an interesting performance profile across the five tasks. She scored highly on the comprehension tasks and also relatively highly on picture naming (table 8.8). However, her performance at naming to definition was much worse than picture naming and she produced no adequate definitions. Two items, *rocket* and *hammock*, were only correct on one comprehension task each. Both of these were on the within-category task, and could have been achieved by recognising the other three items. LO also correctly named six pictures which she did not name to definition.

	naming	CB	CW	TOT	Def.
barge	0	1	1	0	0
trumpet	1	1	1	0	0
shirt	1	1	1	0	0
bath	1	1	1	0	0
tambourine	0	1	1	0	0
van	0	1	1	0	0
cap	1	1	1	0	0
chair	1	1	1	1	0
violin	1	1	1	1	0
apron	1	1	1	0	0
curtains	1	1	1	0	0
car	1	1	1	0	0
wardrobe	1	1	1	1	0
turban	1	1	1	1	0
piano	1	1	1	1	0
rocket	0	0	1	0	0
castanets	0	1	1	0	0
coach	1	1	1	0	0
dress	1	1	1	0	0
sofa	1	1	1	1	0
trousers	1	1	1	1	0
train	1	1	1	1	0
recorder	0	1	0	0	0
hammock	0	0	1	0	0
total	17	22	23	8	0

Table 8.8 Response profile of participant LO on the five tasks scored out of 24.

8.5.6 Subject 6 - LE

Like LO, LE performed well on the two comprehension tasks but produced no adequate definitions (Table 8.9). She also achieved the same scores on both naming tasks, as did DG. Like DG, however, LE did not name the same items on both tasks. She named two pictures that she did not name to definition. She also named two items to their definitions but did not name their pictures. One item, *castanets,* was only right on one comprehension task and so could have been achieved by chance. Once again these inconsistencies do not support item-specific loss.

	naming	CB	CW	TOT	Def.
barge	0	1	1	0	0
trumpet	0	1	1	0	0
shirt	1	1	1	1	0
bath	1	1	1	1	0
tambourine	0	1	1	0	0
van	0	1	1	0	0
cap	0	1	1	1	0
chair	1	1	1	1	0
violin	1	1	1	1	0
apron	0	1	1	0	0
curtains	1	1	1	1	0
car	1	1	1	0	0
wardrobe	1	1	1	1	0
turban	0	1	1	0	0
piano	1	1	1	1	0
rocket	0	1	1	0	0
castanets	0	1	0	0	0
coach	1	1	0	1	0
dress	1	1	1	1	0
sofa	1	1	1	1	0
trousers	1	1	1	0	0
train	1	1	1	1	0
recorder	0	1	1	0	0
hammock	0	1	1	1	0
total	13	24	22	13	0

Table 8.9 Response profile of participant LE on the five tasks scored out of 24.

8.6 Discussion

The findings from this overall analysis reveal that these six PRAD patients are not consistent in their responses to the 24 target items. Participants score highly on the two comprehension tasks. This is not attributable to guessing as the success rate far exceeds the chance level for successfully correctly responding to an item on both tasks. In addition the conditional probability of performing in the same way with an item on both tasks is significant. Success on the comprehension tasks predicts that performance on the generative tasks should be dependent on performance on these two tasks. That is, that items named correctly will also be correctly identified. However, the data do not support this prediction. Thus, some items were correct on the naming tasks that were not correct on the comprehension tasks.

The high level of comprehension performance suggests that semantic representations are largely intact. Additionally, the finding that some items that are failed on the easier tasks can still be defined supports this interpretation. Successful comprehension of items and inconsistent production of their names suggests that lexical representations are also intact. In addition successful word-picture matching indicates that lexical to semantic input connections are intact. As the majority of erroneous responses are semantically related to the targets this suggests that there is a problem in successfully retrieving the target lexical item. In addition, the finding that semantic to lexical output connections are impaired is supported by the relatively reduced production of item names in category fluency. Thus the data suggest that the lexical items are intact, the semantic representations are intact with input connections between the two functioning but with output connections apparently impaired.

The analysis of the consistency data reported in this chapter support the findings in Chapter 6. Of the four hypotheses derived from a two-stage model of lexicalization, only the hypothesis that semantic to lexical output links are impaired in PRAD patients. However, at the end of Chapter 6 I suggested that an additional factor which may influence the performance of these participants may be their ability to recognise and meet the requirements of each task.

Bayles et al. (1991) interpreted their findings of PRAD performance across tasks as reflecting task-specific impairments in performance. Their hypothesis predicts that inconsistent performance will be found across tasks, reflecting the different requirements of the tasks. Thus the data reported here appear to support this hypothesis. However, the Bayles et al. (1991) account predicts differences related to task difficulty. That is items may appear lost on certain tasks because those tasks are too difficult for the PRAD patient to successfully complete. On easier tasks, correct responses to these items should be found. Thus this "task difficulty" hypothesis, like the "item loss" hypothesis, predicts failure on the definitions task if items are failed on the easier tasks.

One participant, LJ, adequately defined three items that she did not respond to correctly on any of the other tasks. Also, her defining performance was proportionally higher than the other participants, relative to her increased severity. In addition DG adequately defined one item that was not correct on all of the other tasks. Similarly, two of the items adequately defined by GI were not correct on all of the other, easier tasks. These findings do not meet with the predictions of the 'task difficulty' hypothesis. LJ's performance in particular, is most interesting. Her MMS and comprehension scores suggest she is fairly severely deteriorated. LJ should be most likely to exhibit reduced performance on more difficult tasks. However, the finding that she actually performs better on the definitions task than some of the other, less deteriorated participants, does not fit with this explanation.

However, Bayles et al. (1991) estimated that the definitions task is easier than confrontation naming. The difference in findings between their study and the present one could be in the rating procedure used to determine definition adequacy. The definition rating criteria are based on the WAIS-R vocabulary subtest in both studies but Bayles et al. (1991) do not explain exactly how they applied these. One reason that the PRAD definitions in Experiment 7 received low adequacy ratings could be that they were presented together in sets. Thus one person's complete set of definitions of the 24 target items were rated together. As the booklets also contained control definitions, it could be that whole sets were judged to be less adequate. It may have been better to mix the definitions so that control and PRAD ones were randomly ordered not by sets but by individual definitions. However, it could equally be that Bayles et al. (1991) used more lenient criteria in rating the definitions.

This discrepancy suggests a problem with predicting the exact order that tasks will become too difficult for PRAD patients to perform, which is the essence of the Bayles et al. (1991) account. Their explanation is that individual tasks are of varying difficulty and that performance will deteriorate until only simple, automatic skills are left. While failure at naming preceded failure at defining in 180 of 263 instances, in the other 83 naming was preserved in the face of definitional loss (Bayles et al., 1991). However, this does not rule out an explanation based on impaired ability to meet task requirements. An alternative account might be that what is impaired is the higher level, executive ability that deals with conventional responding to tasks. It is a noted feature of PRAD that subjects commonly give multi-word responses in tasks requiring single words (Abeysinghe et al., 1989; Obler & Albert, 1979; Santo Pietro & Goldfarb, 1985). Additionally, in the picture-word matching tasks used here, it was noticeable that PRAD participants would spontaneously name the pictured items that they recognised, even though this was not a requirement of the tasks.

In addition the responses in the definitions task suggest that the input, an item's name, activates information about the item, but that there is a failure to recognise the requirement to produce a conventional definition. Thus, the information produced is only sometimes adequate in meeting this convention. Young children do not produce adult-like, Aristotelian noun definitions as they have not yet learnt the convention for doing so (Snow, 1992). In addition, they lack the metalinguistic skills to organise and retrieve the information needed to meet this convention (Bialystok & Ryan, 1985). Young children do, however, provide definitions. PRAD patients, like young children, appear to have the required information but their location and retrieval skills for this information are impaired. Additionally, they seem to no longer be aware of the conventions of providing a definition. Their responses suggest an interpretation of the requirements as "tell me what you know about X" rather than recognising that certain information is conventionally supplied in this task. Thus, their definitions differ in the types of information included. This lack of awareness of the conventional requirements of a definition, may also explain the reduced amount of information provided.

How are PRAD participants able to adequately define low frequency atypical words? These items are quite distinct and have few close semantic co-ordinates. Healthy young adults define them more successfully than high frequency typical items. So, if PRAD participants produce salient information about atypical low frequency items, they are more likely to produce an adequate definition. If only a little salient information is produced about high frequency, typical items, then it is not so likely that an adequate definition will be produced, because more information is needed to differentiate these items from their close semantic co-ordinates.

The reduced ability to monitor speech output found in PRAD participants provides further evidence of an impaired awareness of meeting task requirements in PRAD. Thus, PRAD patients are not aware that they have not provided sufficient relevant information to adequately define an item. The repetitions made in PRAD responses in category fluency also suggest a reduced ability to monitor their speech output. These findings suggest a regression in higher level functioning to a less constrained state of understanding of task requirements.

Chapter 9

Follow-up experiments

9.1. Introduction

The two studies in this chapter arose directly out of the previous seven experiments. They both address methodological issues. Experiment 8 is a third TOT study using non-dementing adults under 65, to investigate if responses are in any way influenced by response mode. Thus do written and spoken responding produce different distributions of responses to the same definitions? In Experiment 9, the target and substitute pairs from Experiments 1, 2, 4 and 5 are scored for semantic relatedness.

9.2 Experiment 9 - TOT 3

9.2.1 Introduction

The advent of experimental techniques to elicit TOTs has permitted the collection and analysis of large amounts of data. Alongside responding to definitions of rare words (Brown & McNeill, 1966), other techniques include naming photographs of famous people (Yarmey, 1973) and answering trivia questions (Lovelace, 1987). The numbers of TOT states recorded as a proportion of all responses varies quite considerably between studies (see Table 9.1).

The various experimental techniques used have resulted in TOTs accounting for between 9.8% and 23% of responses in young adults and between 10.5 and 26% in elderly subjects. There are some difficulties in making direct comparison between studies, as some include negative TOTs (Brown & McNeill, 1966) - where TOTs are resolved but not with the target - and others exclude them. In addition some studies combine TOTs with feeling-of-knowing (FOK) ratings. The figures reported above are after adjustment for negative TOTS.

Author(s) (date)	method/time period	subjects	no. TOTs
Experimental studies:			
Brown & McNeill (1966)	definitions of rare words	young adults	13%
Rubin (1975)	B&M's best four words	young adults	10%
Koriat & Lieblich (1974, 1975, 1977)	definitions	young adults	11%
Yaniv & Meyer (1987)	definitions (2 studies)	young adults	18%, 15%
Jones & Langford (1987)	definitions	young adults	19.8%
Jones (1989)	definitions	young adults	9.8%
Perfect & Hanley (1992)	Jones' definitions	young adults	23%
,,	other definitions	young adults	23%
Meyer & Bock (1992)	Jones' definitions (3 studies)	young adults	13.3% 14.6% 15.1%.
Harley & Bown (1994)	definitions	young adults	19.9%
Kozlowski (1977)	definitions (2 studies)	young adults	15%,* 13%*
Yarmey (1973)	famous names	young adults	14%
Lovelace (1987)	trivia questions	young adults	21%
Maylor (1990)	Jones' definitions	elderly	10.5%
Finlay & Sharp (1989)	trivia questions	elderly	26%
Burke et al. (1991)	trivia questions	elderly	11%
Diary studies:			
Sunderland, Watts, Baddeley & Harris (1986)	per week	elderly	2
Cohen & Faulkner (1986)	per week	young adults mid-age elderly	2.04 1.95 4.02
Burke et al. (1988)	per month	young adults elderly	3.9 6.1
Burke et al. (1991)	4 weeks	young mid-age elderly	3.9 5.4 6.6

Table 9.1. Naturalistic and experimental TOT studies.

* excluding "negative TOTs", which are TOTs not resolved with the target item (Brown & McNeill, 1966).

Diary studies, where naturally-occurring TOTs are recorded, suggest that TOTs occur more frequently with age. Spontaneous TOTs occur about twice a week in young adults and between four and six times a week in the elderly. However, diary studies are the poor relation of experimental methods in terms of yield. There are clear advantages of experimental methods that offer large amounts of data from large numbers of subjects in a relatively short space of time.

In order to test large numbers of subjects, many of the above studies have used verbal presentation of the stimuli and written recording of the responses. This is particularly so with the definitions method of eliciting TOTs. Participants are supplied with response sheets with instructions to supply targets, indicate TOTs, and often additional information about the target if they feel they are in a TOT. This allows testing of large numbers of subjects at the same time. Alternative methods include computer presentation in the form of forced choice responses to trivia questions (Burke et al., 1991) and naming pictures (Yarmey, 1973).

As pointed out in Experiment 2, the discrepancies in numbers of TOTs reported could arise from using the written response format, which encourages participants to record FOKs as TOTs. Perfect and Hanley (1992) note that they specifically instructed subjects not to record a TOT if they just felt that they knew the word. However, the large difference between subjective and objective TOTs in their studies, suggests that this instruction may have been ignored. The TOT/FOK relationship has been commented on by other researchers (Maylor, 1990; Yaniv & Meyer, 1987).

In Chapter 4 I predicted that the PRAD subjects would make large numbers of TOT responses. I based this prediction on the numbers of TOT states reported with young adults in studies such as those above and the noted retrieval difficulties of PRAD sufferers (Miller, 1975). They did have more TOTs than the elderly control subjects in the study, but the number made by both groups (12% PRAD and 5.5% controls) was considerably less than the numbers reported in the majority of previously mentioned studies. As other studies have reported that older adults have more TOT states than younger adults (Burke et al, 1991; Cohen & Faulkner, 1986), these results were surprising.

One possible explanation lies in the difference in methodology between my experiments and most of the other studies. Definitions were used, as in the majority of studies, and were presented verbally and visually as well whenever possible. Participants were tested individually and responses were spoken. Only one other study has used spoken responding (Kohn et al., 1987). They tested only a small group of subjects (all undergraduates) and the way in which they coded responses makes direct comparison with the TOT studies reported here (Chapter 4, Chapter 5) difficult. However, this study is important because Kohn et al. (1987) assert that TOTs indicate a break-down in spoken not written language. Thus, they claim, using written responses is a limited way of investigating the phenomenon. Is it, though, a reliable method of investigating TOTs?

This study aims to address this question. Young, healthy adults were randomly divided into spoken- and written response groups. As the definitions from TOT 1 and TOT 2 were selected for use with PRAD participants and are of a higher frequency than words used in previous studies (e.g. Brown & McNeill, 1966; Jones, 1989), a third, low frequency, set of items is also included. It is expected that the participants will produce the target word for most of the high and medium frequency items. The critical data will therefore be the responses made to the low frequency items. If the response mode has an influence on responding, then the written group should record more TOTs than the spoken response group to these targets.

9.2.2 Method

Subjects. These were 18 adults, aged between 18 and 45, with a mean age of 25:8 years. Their years of education ranged between 13 and 20, with a mean of 14.8 years. These volunteers were recruited from the Psychology Department subject pool, from first year Methods classes and through posters around the Psychology department. All participants were paid £1.50.

Materials. These comprised definitions of 96 words, 32 high frequency (more than 20 times per million), 32 medium frequency (between 1 and 20 times per million) and 32 low frequency (between 1 per million and 1 per four million). The high and medium frequency items are taken from the two previous TOT studies, Experiments 2 and 6, each supplemented with 8 additional items each. The low frequency items are from Jones (1989; see Appendix XX).

Procedure. The subjects were randomly divided into two groups.

Group One. Subjects in this group were tested individually with the experimenter reading out each definition in turn. Both manual and audio recordings were made of the verbal responses. Definitions were presented when subjects responded to the previous one, resulting in a presentation rate of about one every 30 seconds. Participants responded quickly to the high and medium frequency targets. Definitions were repeated as requested by participants and as much time as required was allowed when subjects indicated they might be in a TOT state or wanted to think further about the definition, which happened often with the low frequency definitions.

Group Two. This group was tested together with the experimenter again reading out all of the definitions. Each participant had a booklet with space for 96 responses. The first column of the response sheet was for the target word. A second column was provided for indicating the presence of a TOT. Subsequent columns asked for initial letter of the elusive target, the number of syllables and any other information that could be supplied. Definitions were read out at a similar pace to the individual test situation, with repetitions as requested. As much time as required was allowed, with subjects indicating when they were ready to move on to the next definition.

9.2.3 Results

As in Experiments 2 and 5, the responses were divided into the five types of *target*, *don't know*, *TOT*, *own-target word* and *constructive search*. In the written response group, when subjects wrote more than one word, sometimes crossing one or more out, this was rated as a constructive search. It was reasoned that the subject had not immediately thought of the word, or was not entirely sure which of several possibilities the answer could be.

SPOKEN	target	don't know	TOT	OTW	CS
High freq.	233	11	-----	40	4
Medium	226	10	1	39	12
Low	100	53	13	100	22
total	559	74	14	179	38
mean response	62.11	8.22	1.55	19.89	4.2
% response	65%	8%	2%	21%	4%

WRITTEN	target	don't know	TOT	OTW	CS
High freq.	235	7	7	32	7
Medium	226	16	8	29	9
Low	88	75	42	77	6
total	549	98	57	138	22
mean response	61	10.89	6.3	15.33	2.4
% response	64%	11%	6%	16%	3%

Table 9.2. Distribution of responses made by each group to the words of each type. Totals of each response type, means and percentage of total responses that each accounts for are included.

Key: TOT = tip-of-the-tongue OTW = own target word CS = constructive search

As expected, the most common response made by both groups was production of the target word, with own-target words the second largest response (see Table 9.2). "Don't know" and constructive search responses accounted for 12% of the spoken group's responses and 14% of the written group. TOT responses accounted for only 2% of responses made by the spoken-response group, and 6% of the written group. The distribution of response types by the two groups for the three different word frequencies was compared by analysis of variance. A 2X3 (group X frequency) unrelated analysis of variance was carried out for each of the five response types.

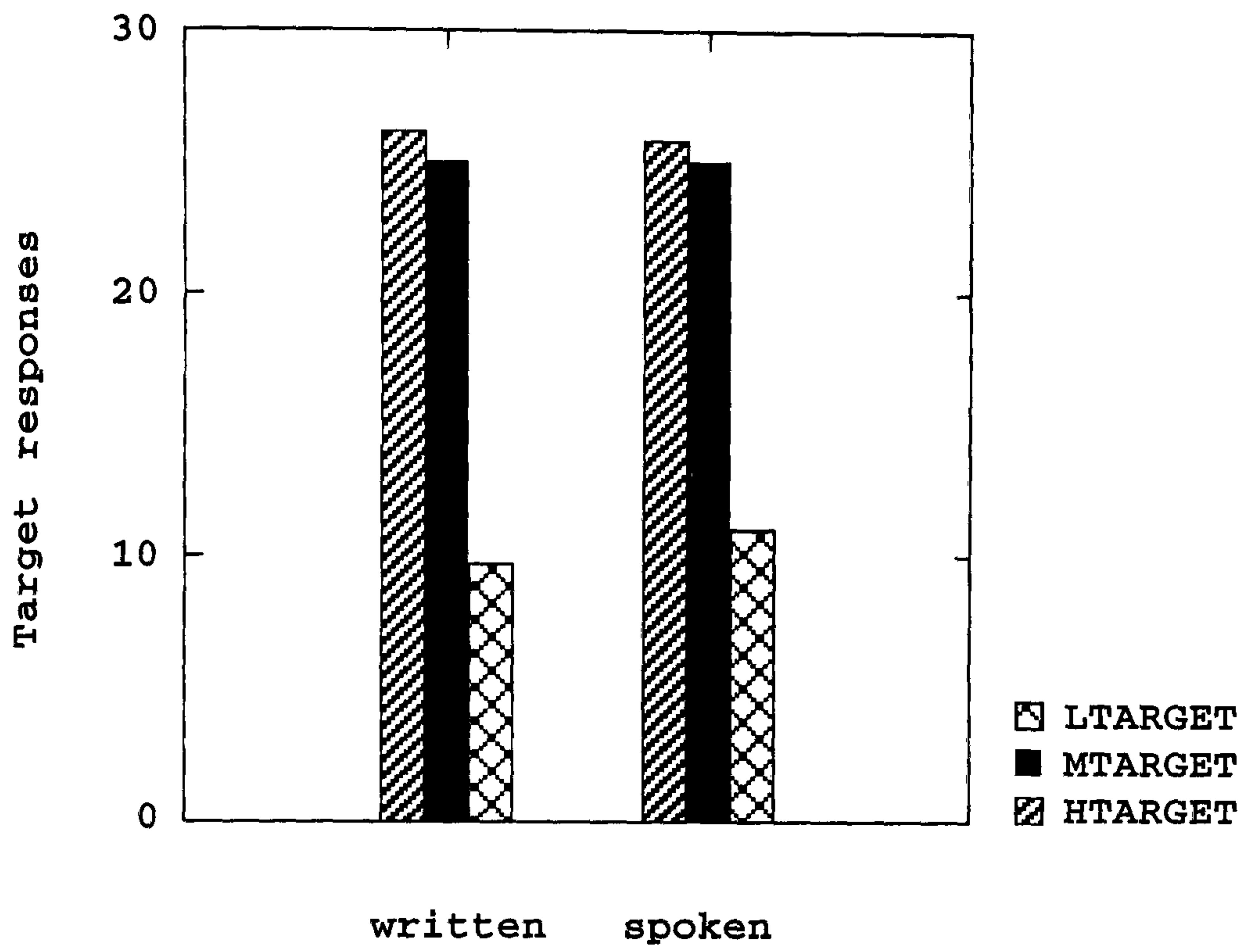


Figure 9.1. Distribution of target responses to the high, medium and low frequency definitions.

Production of the target word for the three word frequencies shows a similar pattern in both groups (Figure 9.1). Analysis of target word responses showed no main effect of group. There was a significant main effect of frequency, ($F(2, 32) = 215.08$, $p < 0.0005$), showing a significant difference in production of the target words between the three frequency types. There was no interaction effect. Tukey tests showed that the difference in target responses among the three frequency types, lay between the low frequency targets and the two higher frequency words ($p < 0.0005$).

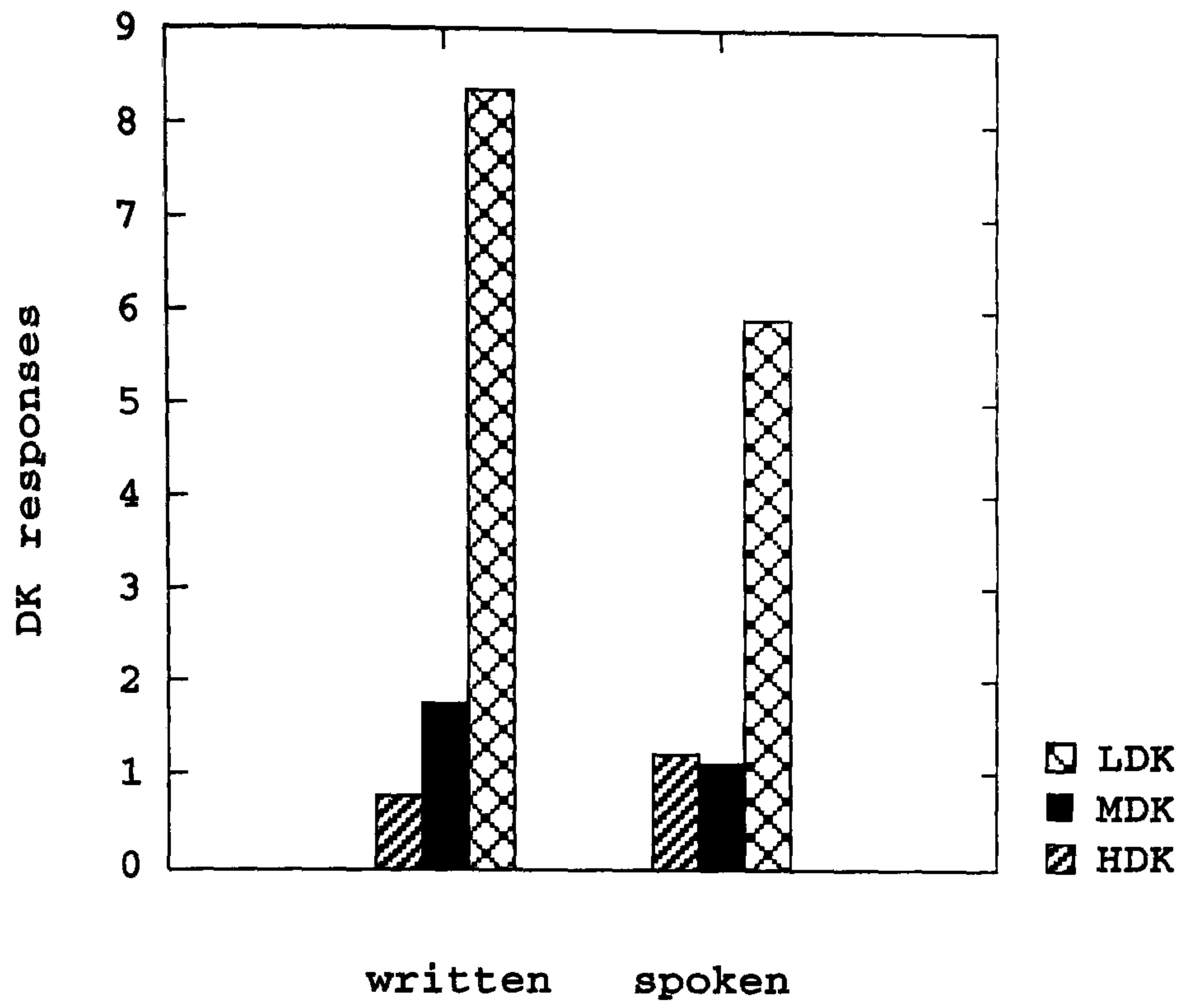


Figure 9.2. Distribution of "don't know" responses to the high, medium and low frequency definitions.

As expected, both groups made few "don't know" responses to the high and medium frequency targets (Figure 9.2). In the analysis of "don't know" responses there was no main effect of group. There was a main effect of frequency ($F(2, 32) = 44.29$, $p < 0.0005$). There was no interaction effect. Tukey tests showed that the significant difference in the means lay between the low frequency words and the other two frequencies ($p < 0.0005$). The distribution of TOT responses to the three word types is shown in Figure 9.3. There was no main effect of group. There was a significant main effect of frequency ($F(2, 32) = 17.84$, $p < 0.0005$). There was also a significant interaction effect ($F(2, 32) = 3.90$, $p < 0.05$). Tukey tests revealed that the number of TOT responses to low frequency definitions differed from both medium and high frequency definitions ($p < 0.0005$). Analysis of the interaction showed that the number of TOTs recorded by the written group to the low frequency words differed significantly from the number of TOTs recorded by the spoken response group to all three frequencies ($p < 0.0005$).

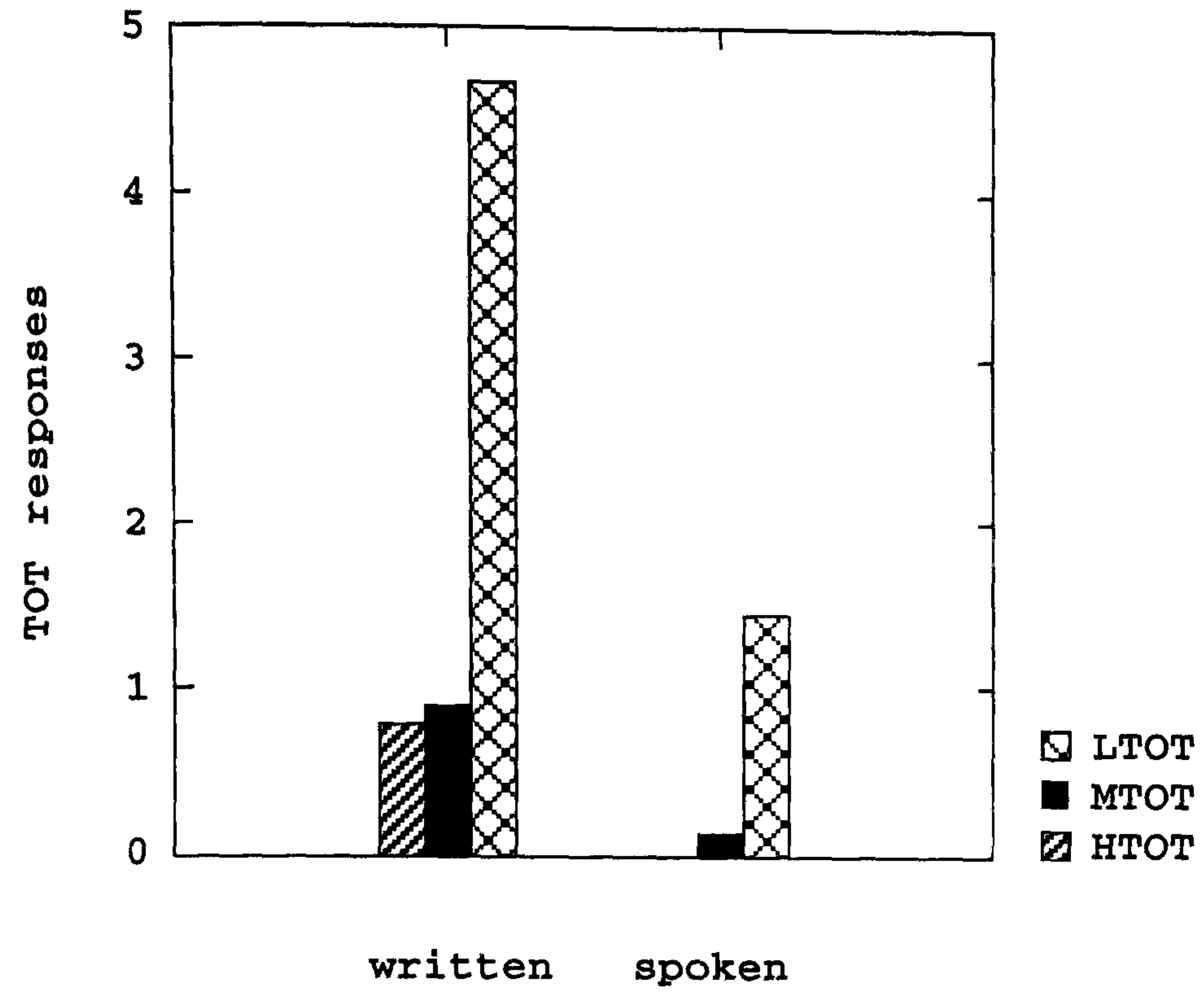


Figure 9.3. Distribution of TOT responses to the high, medium and low frequency definitions.

Using the criteria outlined by Jones and Langford (1987), TOTs recorded by the written-response group were divided into subjective and objective TOTs. Subjective TOTs are those responses where a participant simply ticks the 'TOT present?' column. Objective TOTs are those subjective responses where the participant reported one or more piece of information about the TOT target (such as initial letter) and this information was correct. Of these 57 responses, information about the elusive target was offered in 33, with this information being correct in only 12 instances. Thus only 12 recorded TOT states, or 1.4% of total responses by the written group can be classed as objective TOTs.

Own-target responses occurred less for the high and medium frequency targets among the responses of both groups (Figure 9.4). Analysis of own-target responses showed no main effect of group. There was a significant effect of frequency ($F(2, 32) = 47.56$, $p < 0.0005$) but no interaction. Tukey tests indicated that the difference in means lay between the own-target responses to low frequency definitions and these responses to the medium and high frequency definitions ($p < 0.0005$).

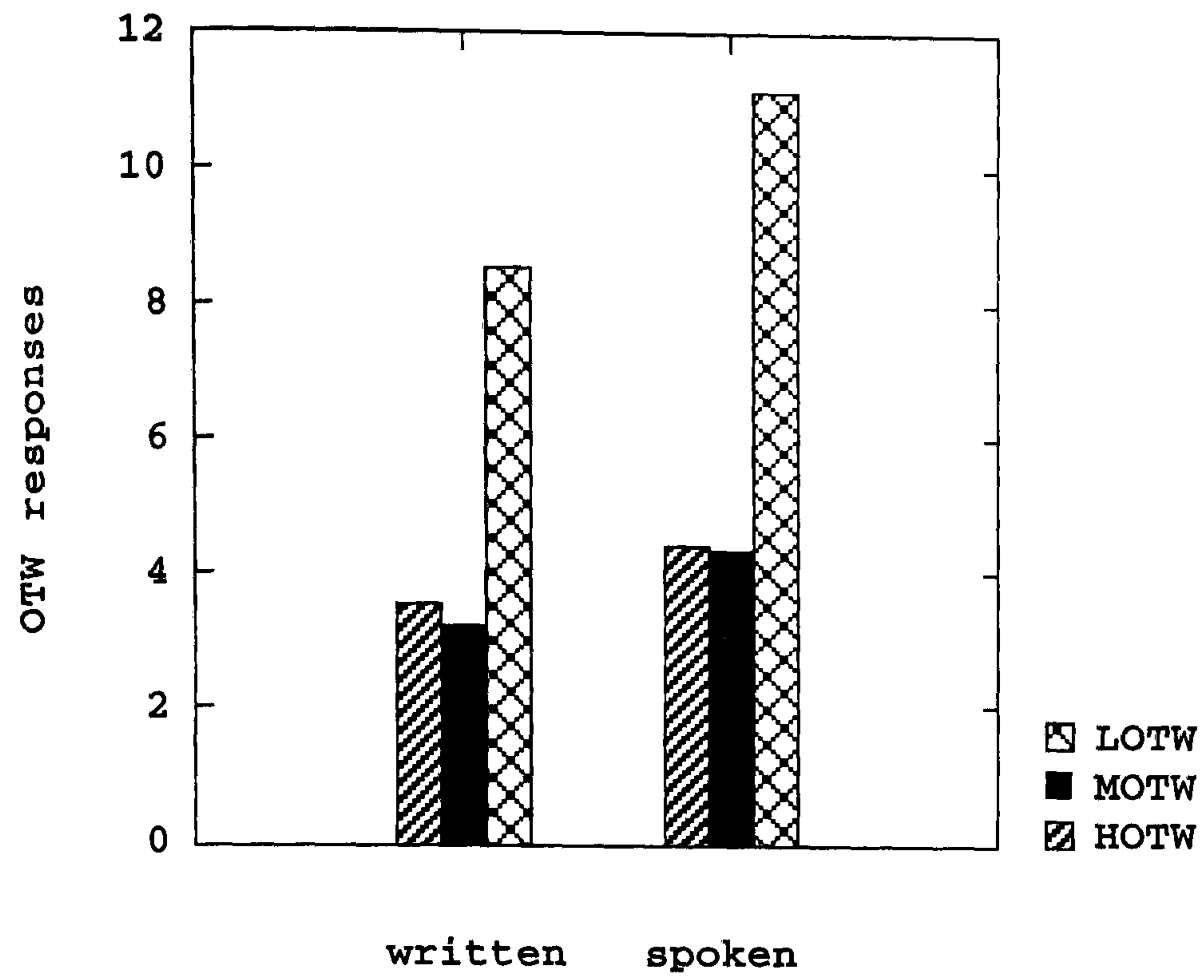


Figure 9.4. Distribution of own-target responses to the high, medium and low frequency definitions.

The two groups produced different patterns of constructive search responses to the three word frequencies (Figure 9.5). The analysis of these distributions showed no significant main effect of group. There was a significant main effect of frequency ($F(2, 32) = 3.74$, $p < 0.05$) and also a significant interaction effect ($F(2, 32) = 4.83$, $p < 0.01$). Tukey tests indicated that the difference in means lay between the high and low frequency definitions ($p < 0.03$). Tukey tests on the interaction indicated that the number of CS responses produced by the spoken group to the low frequency words differed from the number of CS responses made by the written group to all three frequencies (high, $p < 0.005$; medium, $p < 0.01$; low, $p < 0.001$).

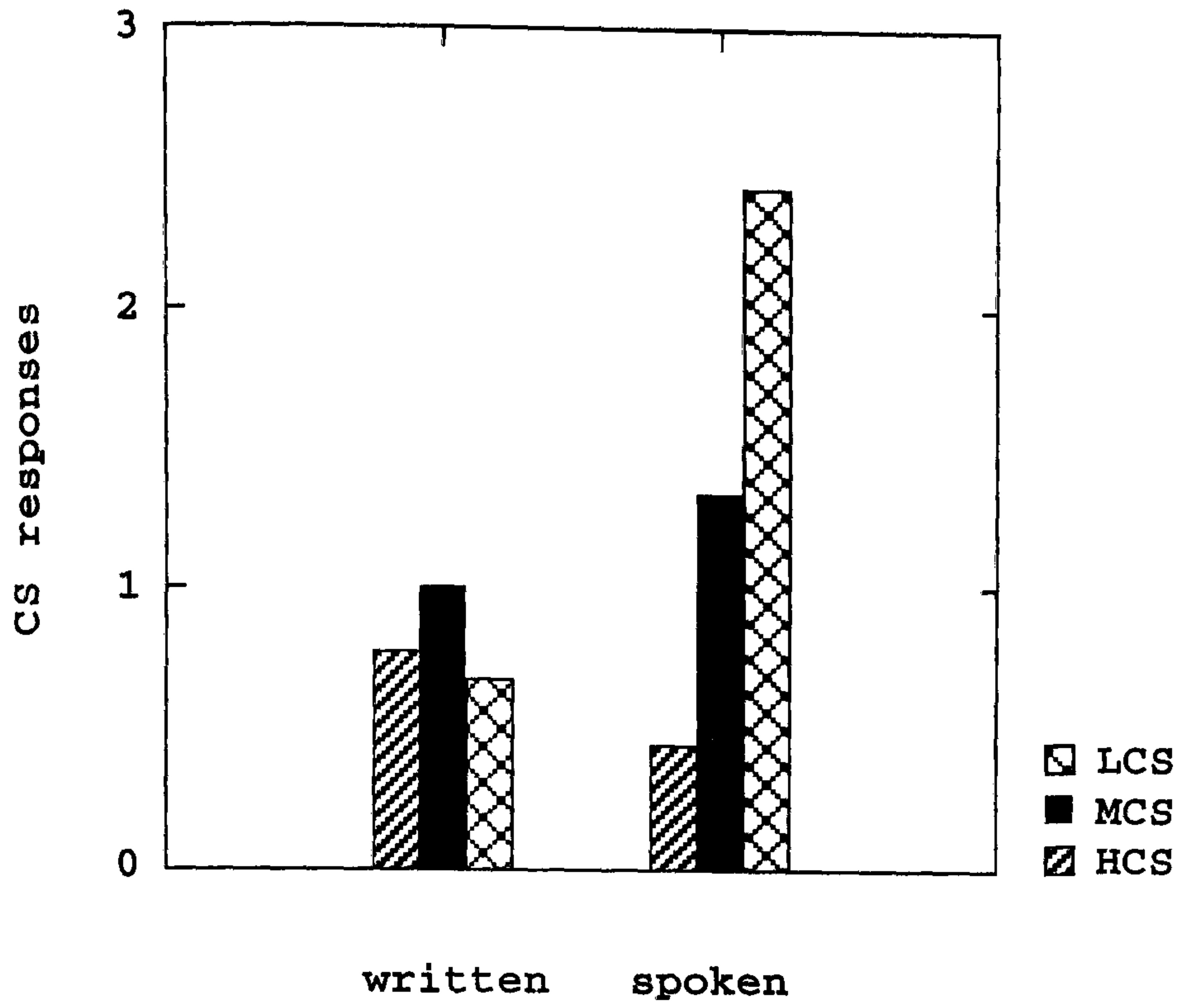


Figure 9.5. Distribution of constructive search responses to the high, medium and low frequency definitions.

9.2.4 Discussion

The performance of the two groups was similar on the high and medium frequency words, with production of the target the most frequent response. On all response types, differences were found between the high and medium frequency words and the low ones. Particularly important are the number of TOTs recorded by the two groups and the number of constructive search responses. The written response group recorded significantly more TOTs to low frequency words than the spoken response group. Of the total TOTs recorded by the written group, however, only 1.4% were judged to be objective TOTs. The spoken group recorded significantly more constructive search responses to the low frequency words. Thus, on the difficult, low frequency words, the spoken group did not have TOTs but rather tried to work out what the answer could be. For these same words the written response group recorded TOTs, but offered very little information about the targets to support this claim. These findings support the notion that in written response studies, a substantial proportion of claimed TOTs are actually FOK responses. The conclusion is therefore that the written response format encourages subjects to record TOT states when the think they know a word and are not really in a TOT state.

In this study objective TOTs of 1.45% (written) and 2% (spoken) compare with 5.5% and 5% (healthy elderly, Experiments 2 and 5 respectively) and 12% and 9% (PRAD Experiments 2 and 5 respectively). From these results, the findings of Experiments 2 and 5 can be seen as an accurate reflection of TOT states being greater in the elderly than in young adults and higher still in PRAD.

9.3 Experiment 9 - Semantic relatedness

9.3.1 Introduction

This experiment was carried out to collect independent ratings of the semantic relationship between all the target and substitute pairs produced in Experiments 1, 2, 4 and 5.

9.3.2 Method

Subjects. Fourteen participants aged between 19 - 39, with a mean age of 22 took part. Their mean years of education were 15.35, with a range of 13 - 19 years. Volunteers were recruited partly from the Psychology department subject pool, partly from a direct approach to first year undergraduates and also by posters around the Psychology department. All participants were paid £1.50.

Materials. These comprised a 10-page booklet containing 379 word pairs, of which 339 were collected from Experiment 1, Experiment 2, Experiment 4 and Experiment 5 and a further 40 pairs were made by matching the target items randomly with substitution words from the above four experiments. Each page comprised six columns, with the first containing the word pairs. The subsequent five contained the numbers 1, 2, 3, 4, 0 with appropriate headings instructing how to use each mark.

Procedure. Participants each received a booklet and an explanation of the scoring system as follows: In this booklet you will find pairs of words. Please assign a value between zero and four using the following criteria: 1 - No link: the meanings of the words are completely unrelated; 2 - Far-fetched link: the meanings of the words are related in some way; 3 - Weak link: the meanings of the words are slightly related in some way; 4 - Strong link: the meanings of the words are fairly closely related in some way; 0 - where the meaning of one or both of the words is unknown (these criteria were based on Jones, 1989). Participants were told to take as much time as they wanted.

9.3.3 Results and Discussion

The scores assigned to each pair were averaged to produce a mean semantic rating (see Appendix XXI for random pairs and ratings). Pairs with ratings between 1 and 1.49 are considered to have no link and of 1.5 or more have some semantic relationship. Between 1.5 and 2.49 are pairs considered to have a far-fetched link; between 2.5 and 3.49 pairs with a weak link;.between 3.5 and 4 pairs with a strong link (Table 9.2).

mean rating	1 - 1.49	1.5 - 2.49	2.5 - 3.49	3.5 - 4
Naming I	15 (20%)	8 (10.5)	30 (39.5%)	23 (30%)
TOT I	6 (4.5%)	30 (23%)	55 (41.5%)	41 (31%)
Naming II	14 (29%)	5 (10.5%)	21 (44%)	8 (16.5%)
TOT II	9 (11%)	22 (26.5%)	37 (44.5%)	15 (18%)
Total (%)	44 (13%)	65 (19.25%)	143 (42.25%)	87 (25.5%)

Table 9.3 Distribution of target-substitute pairs across the bands of semantic relatedness. Percentage in parentheses.

The majority of pairs (87%) have some semantic relationship. Most of the unrelated pairs are in the two naming studies and are those pairs judged to be visual errors. Additionally, two other pairs rated as semantically unrelated have a phonological relationship. The proportion of responses in the weak-link band (2.5-3.49) is fairly constant across all four tasks at just over 40%. It is noticeable that there are fewer strong-link (3.5-4.0) responses in the second naming and TOT tasks than in the first two studies.

In all four tasks, the mean relatedness of the pairs, excluding the visual errors from the naming tasks, is higher than the rating of the random word pairings (see Table 9.3). Visual errors were removed as they all received low semantic ratings, confirming their visual origins. The low mean rating of the random pairs indicates that the scoring system has adequately separated the pairs.

Naming I	TOT I	Naming II	TOT II	Random
3.225*	2.944	3.006*	2.744	1.16

Table 9.4 Mean semantic relatedness ratings for each task and for the random word pairs.

Visual errors removed.

The main purpose of this experiment was to gain independent ratings of the semantic relationship between word pairs. The scoring system used successfully separated the unrelated, randomly paired words. It also identified the semantically unrelated visually based errors in the two naming tasks. In all four tasks the majority of items have a semantic relationship. However, the average rating of semantic relatedness in each task was of a weak link between the words, not a strong one.

Chapter 10

Conclusions

I collected the data in this thesis to answer two questions. These are "how is language affected by dementia?" and "What is the particular effect on speech production?". In attempting to answer these questions a variety of issues were identified which these data address. First, is whether language impairment reflects underlying semantic disturbance. Second, is whether lexicalization is a one-or two-stage process. Third, is how many lexicons do we have and what is the relationship between input and output processes in language? Fourth, is the locus of frequency effects. In this concluding chapter I examine the implications of the findings reported here for these four issues.

10.1 Semantic impairment

The most common approach to understanding speech disorder in PRAD is to view it as reflecting an underlying semantic disturbance. There are two variants of this, both of which have been proposed to account for PRAD data. First, and the more often suggested, is that semantic representations are impaired (Chertkow & Bub, 1990a, b; Hodges et al., 1991, Hodges, Salmon & Butters, 1992, 1993; Huff et al., 1986; Martin & Fedio, 1983; Salmon et al., 1987). Thus item-specific semantic information is lost, resulting in failure to produce target items. Second is the suggestion that semantic representations are intact but that the processes that access them are impaired (Nebes et al., 1984; Diesfeldt, 1985). The data presented here offer support for the impaired access account.

These data meet three of the four criteria proposed by Warrington and Shallice (1979) to distinguish between access and storage disorders. First, there was no tendency in semantic substitutions, the major error type, for low frequency items to be substituted with higher frequency ones. Second, there was no tendency to substitute subordinate category members with superordinates. Third, response patterns to individual items are not consistent across tasks. The fourth criteria, that priming will facilitate production in an access disorder, was not addressed by these data.

These data suggest that semantic errors do not always indicate a semantic impairment. This hypothesis has also been proposed to account for semantic reading errors in deep dyslexia (Jones & Martin, 1985). Whilst their adherence to the 'right-hemisphere hypothesis' of deep dyslexia is controversial, the idea that it is the processes rather than the representations that are impaired is acknowledged (Marshall & Patterson, 1985). The data collected from PRAD participants reinforces this hypothesis, at least with regard to the interpretation of semantic errors, if not for the substitution of usually suppressed mechanisms when normal processing is impaired.

10.2 Lexicalization

As explained in Chapter 2, the two semantic hypotheses (i.e., storage or access) derive from one-stage models of lexicalization where concepts and concept labels are part of the same semantic information. In addition, there are one-stage models which have lexical items stored at the phonological level (Allport & Funnell, 1981; Fay & Cutler, 1977). In Chapter 3, I reviewed the evidence for both types of one-stage models and for two-stage models. My conclusion was that two-stage models can best account for all of the psycholinguistic and neuropsychological data available. This conclusion is in line with the approach found in most current research on speech production.

In this thesis I have attempted to apply a two-stage model to speech in patients with dementia. A two-stage model, with semantic and lexical information stored separately, best explains the data I collected. Comprehension performance is better than production. This suggests the separate storage of concepts and labels with semantic items sometimes activated but their corresponding lemmas not. There is no evidence of phonological disturbance in PRAD, which also supports the two-stage separation of lexical and phonological representations.

The disrupted semantic access account translates in a two-stage model to disrupted semantic to lexical processing. This is the explanation supported by the data from each generative task. Thus the adoption of a two-stage model of lexicalization rather than a one-stage does not alter the explanatory power of the disrupted access hypothesis. Indeed, this model clarifies the nature of the impairment by isolating the locus of impairment.

10.3 Input and output processes

The introduction of a two-stage model of lexicalization raised the issue of how many lexicons we have. As explained in Chapter 3, this question necessitates consideration of both input and output processes. I identified two separate questions relating to this issue that arise from two-stage models. First, whether one lexicon serves both input and output processes, and second whether speech perception and production share the same phonological representations and whether reading and writing share the same orthographic representations.

In response to the first question a single lexicon serving both input and output processes can explain the data presented here. There is no evidence that requires separate lexicons for input and output and on grounds of parsimony a single lexicon is preferable. The high number of definitions with some information and high levels of comprehension performance suggest that *input* connections between lexical and semantic items are intact. The lower level of production on category fluency supports the notion of a problem retrieving lexical items for output. This accords with the suggestion of Allport and

Funnell (1981) that different processes using the same representations but different pathways may show differential impairment.

The second question requires a more detailed consideration of the data. The complete set of tasks used tested a whole range of skills. The CAPE, the three-stage command component of the MMSE, (to take, fold and place a sheet of paper on the floor) visual lexical decision and TOT 1 all rely on reading. Both the MMSE task of writing a sentence and the CAPE requirement that participants write their name provide limited tests of writing. The sentence writing also provides a limited measure of syntactic skill. The MMS contains a figure-copying task, providing a limited measure of drawing ability. A measure of motor control is the Gibson spiral maze component of the CAPE. Picture-word matching, auditory lexical decision, category fluency and TOT 2 provide measures of auditory comprehension. Single word production is measured on picture naming, naming to definition and category fluency (serial single word production). The definition task provides a measure of production of strings of words. Picture naming and picture-word matching test visual pictorial comprehension The comprehension, naming, TOT and defining tasks all measure recognition. In addition the MMS provides a limited measure of recall.

To answer the question posed above I will only consider data from the tasks using orthographic and phonological representations. Reading appeared to be intact in all participants who carried out tasks reliant on it. This accords with other findings of preserved reading ability in PRAD (Cummings et al., 1986; Fromm et al., 1991; Funnell & Hodges, 1991; Nebes et al., 1984; O' Carroll & Gilleard, 1986; Stebbins et al., 1990). Reading uses either input orthographic representations or input pathways from orthographic representations to semantic and lexical representations. There is evidence of writing impairment with 15% of the PRAD participants no longer able to write and at least half showing some impairment. This is in line with other reports of impaired writing ability in PRAD (Appell et al., 1982; Rapcsak, Arthur, Bliklen & Rubens, 1989). With an account favouring separate orthographic representations for reading and writing, impaired writing relative to reading arises from impaired output orthographic representations. In a shared orthography account, impaired writing results from disrupted output pathways.

On the picture-word matching tasks PRAD participants performed well suggesting either intact input phonological representations or intact input pathways from phonological representations to lexical forms. PRAD participants made more errors on auditory lexical decision than on visual. They found it hard to reject plausible-sounding nonwords and would often ask if the nonword was spelt in a certain way. This suggests that their failure does not arise at the level of phonological input, as this question indicates processing at the lexical level. On the category fluency task, every participant produced at least one relevant item, with most producing several suggestions. This supports the idea that the input phonology was processed and that impaired performance on this task arises from disruption of higher level processes (Bandera et al., 1991; Chan et al., 1993; Chertkow & Bub, 1990a; Diesfeldt, 1985; Hodges, Salmon & Butters, 1992; Huff et al., 1986; Nebes, 1989; Ober et al., 1986). On TOT 2, the majority of nontarget responses were semantically related to the target rather than being unrelated or "don't knows", which suggests that the definitions were understood. This also supports intact phonological representations in input processes.

On the three measures of single word production, the PRAD participants were impaired relative to age-matched controls. However, I interpret the lack of phonological errors and predominance of semantic errors as indicating impaired semantic to lexical output rather than impaired phonological processing. Thus output phonological processes appear to be intact. On the definition task problems arise at the level of information selection and retrieval not of output phonology. Overall the data are do not distinguish between separate or shared phonological and orthographic representations.

10.4 Frequency and other variables

In Chapter 5 I predicted that there would be no frequency effects in substitutions. That is, substitutions would not be of higher frequency than the targets they replace. The data support this prediction which is based on the lack of phonological errors in PRAD speech. These data therefore support the location of spoken word frequency post-lemma retrieval (Harley, in press; Jescheniak & Levelt, 1994; Nickels, in press).

In considering the influence of frequency, I reviewed the evidence that AOA effects are stronger than frequency (Brown & Watson, 1987; Gilhooly & Watson, 1981). These studies reported tasks with an explicit speech output component. The authors suggest that AOA is located in the phonological store. They argue that earlier acquired words have more complete representations. As children get older they learn the rules and store fragments rather than whole-word phonological forms. This storage parsimony results in a production cost as items that must be generated take longer than those that can be accessed whole. A post-hoc analysis of my data was not possible for target items as they were not selected with AOA as a constraining variable. However, if AOA is located at the phonological level, then I would predict that its influence would be minimal for the same reason as frequency exerted a minimal effect. That is because the speech production problem in PRAD appears to be located earlier in the lexicalization process.

With regard to typicality I predicted that its influence would be most marked in category fluency as it is a semantic variable. In this task PRAD production was reduced relative to age-matched controls and healthy young adults. However, the patterns of item generation were similar to those of controls, suggesting that typicality relationships are preserved in PRAD.

10.5 Disordered speech in PRAD

I return now to my two original questions. Taking first the question of how language is affected by dementia, the participants in this study showed relatively preserved comprehension both for written and spoken words. There is evidence that with increasing severity writing and picture recognition deteriorate. This findings are consistent with the literature. With regard to the particular effect on speech production, syntax and phonology were relatively intact in these patients with the communicative content of speech reduced and the occurrence of many semantic errors in formal testing. Again these findings are consistent with other reported findings.

I conclude that speech production in PRAD is influenced by a combination of factors. At the level of lexicalization, the data suggest that semantic to lexical output processing is disrupted. At the global level of language function, the components, such as phonological and semantic representations are largely intact. However, the ability to manipulate stored representations in response to various tasks is impaired. In formal test situations they are unable to fully recognise and produce the expected response to a task. For instance, PRAD patients understand that they are required to name an item but do not recognise that the conventional response is a single word. Similarly they understand the request to define or describe an item but no longer recognise that there is an accepted format for doing this. In verbal fluency they find it difficult to keep in mind the responses already made. In spontaneous speech the problem manifests as impaired monitoring of output and the content of interchanges (Blanken et al., 1987).

The impairment of higher level functions, such as metalinguistic skills, can be explained by the involvement of the frontal association areas in cortical atrophy in PRAD. Frontal lobe damage results in disturbed attention and concentration, difficulty grasping new tasks whilst retaining competence at well-practised ones, reduced initiation of spontaneous speech, disruption of retrieval processes and problems with self-monitoring. These behaviours have been attributed to failure in resource allocation and supervisory control of attention (Baddeley, 1986; Shallice, 1982).

This explanation, coupled with disrupted semantic to lexical processing in speech production, provides the best account of language function in PRAD. At the end of Chapter 2 I suggested that as PRAD is a degenerative disorder, all four of the possible hypotheses proposed to account for the speech disorder may be seen over time. However, the data suggest that problems occur with processing rather than components, supporting an explanation of progressively impaired higher level cognitive functioning that results in a disintegration in processing. It may not be possible to distinguish if the components also become impaired as the breakdown in processes may make examination of their status impossible. Thus the components of language and cognition may become isolated islands that cannot be tapped by testing due to the breakdown in processing.

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Appendix I **Details of the participants with probable Alzheimer's disease (PRAD) whose data are reported in this thesis.**

Subject	M/F	D.o. B.	years educ	MMS	CAS	dep	BRS	dep	DF	DB
1. ZO	F	28/03/1911	9	14	21	C	5	B	7	3
2. GI	F	28/12/1907	10	18	24	B	7	B	7	4
3. LJ	F	9/11/1913	12	7	12	D	15	D	2	0
4. DG	F	7/06/1910	12	16	22	C	17	D	4	0
5. LO	F	11/12/1911	9	22	23	C	NT	NT	10	5
6. LE	F	16/4/1911	9	8	9	D	NT	NT	5	2
7. ID	F	10/2/1918	10	12	21	C	24	E	NT	NT
8. VA	F	28/04/1903	9	10	21	C	NT	NT	NT	NT
9. US	F	7/02/1905	9	4	6	E	24	E	2	0S
10. IV	M	19/05/1915	12	15	25	B	NT	NT	NT	NT
11. SC	F	14/01/1918	10	20	27	C	8	B	6	4
12. FQ	M	8/02/1908	11	17	20	C	10	C	NT	NT
13. OS	M	13/09/1909	11	NT	NT	NT	NT	NT	NT	NT
14. RA	M	19/04/1921	9	NT	NT	NT	NT	NT	NT	NT
15. FZ	F	9/06/1907	9	NT	NT	NT	NT	NT	NT	NT
16. OF	M	19/06/1905	9	NT	NT	NT	NT	NT	NT	NT
17. ZV	F	23/09/1904	10	11	25	B	4	B	NT	NT
18. CR	F	14/10/1909	9	NT	NT	NT	NT	NT	NT	NT
19. ZB	F	22/02/1906	12	NT	NT	NT	NT	NT	NT	NT
20. BC	F	12/11/1916	9	NT	NT	NT	NT	NT	NT	NT
21. NM	F	23/07/1912	9	9	NT	NT	NT	NT	NT	NT
22. GL	F	18/3/1914	9	NT	NT	NT	NT	NT	NT	NT

Key: MMS = Mini Mental State examination; CAS = cognitive assessment scale (CAPE); dep. = dependency level; BRS = behaviour rating scale; DF = digit span forwards; DB = digit span backwards; NT = not tested.

Accommodation:

Assessment ward: ZO, DG, LO, ID, VA, SC, FZ, ZB, NM, GL

Living at home (Day Hospital patient): LJ, US, IV, FQ, OS, RA, ZV, BC.

Long-stay psychiatric ward: OF

(Moved to) residential care: GI, LE, CR (ZO, DG, LO, ID, VA, IV, ZV, ZB, NM, GL).

Appendix II **Details of the control subjects from whom data are presented in this thesis.**

Subject	M/F	D.o. B.	years	MMS	DF	DB
C1 XY	F	12/12/13	9	30	7	6
C2 GC	F	23/02/13	9	30	6	6
C3 OM	F	31/10/16	16	27	10	4
C4 FV	M	19/07/21	9	30	NT	NT
C5 WT	F	1/11/18	9	NT	NT	NT
C6 OI	F	28/01/20	10	NT	NT	NT
C7 KO	F	14/03/11	10	NT	NT	NT
C8 EJ	F	20/12/08	9	NT	NT	NT
C9 GF	F	10/10/20	10	NT	NT	NT
C10 VR	M	31/03/12	15	NT	NT	NT
C11 IO	M	14/07/16	10	NT	NT	NT
C12 MU	M	09/03/14	12	NT	NT	NT
C13 HL	F	29/03/11	10	NT	NT	NT
C14 XU	F	20/06/11	9	NT	NT	NT

Key: MMS = Mini Mental State examination; years = years of education; DF = digit span forwards; DB = digit span backwards; NT = not tested.

Appendix III **Word and nonword stimuli used in lexical decision tasks. Francis & Kuçera (1982) frequencies are given for the words and for the nonwords the range of frequencies for related words (from the Oxford Psycholinguistic Database, 1992).**

words

FLAG	18
MAT	7
DATE	120
GRASS	55
TREE	160
SHOE	58
BOOK	292
CLOTH	43
COW	46
EYE	524
APPLE '	15
ROBIN	1

nonwords

GATH	gAθ	0 (hath) - 58 (path)
TEG	tEg	0 (cleg) - 126 (leg)
VABLE	veɪ b´ ()l	3(sable) - 252 (table)
CUG	cUg	0 (fug, pug) - 69 (drug)
FANT	fænt	0 (bant) - 631 (want)
WOON	wun	0 (swoon) - 200 (soon)
TANE	teɪn	0 (bane) - 138 (plane)
PUTE	pjut	0 (jute) - 5 (brute, cute)
GED	gEd	0 (led, zed) - 139 (bed)
BOSE	bëøs	20 (pose) - 864 (those)
LUP	lUp	1 (sup) - 1712 (up)
NAKE	neɪk	0 (crake) - 2312 (make)

Appendix IV Noun and verb synonymy triplets from the Philadelphia Comprehension Battery for Aphasia (1989).

(V)	1. to allow*	to encourage	to permit*
(V)	2. to lie	to rob*	to steal *
(N)	3. violin*	fiddle*	clarinet
(V)	4. to scream*	to threaten	to shout*
(N)	5. lake	brook*	stream*
(V)	6. to rip*	to tear*	to slice
(V)	7. to strangle*	to murder	to choke*
(N)	8. automobile*	train	car*
(V)	9. to preach	to instruct*	to teach*
(N)	10. thief*	spy	robber*
(N)	11. shack*	hut*	tent
(V)	12. to repair*	to fix*	to design
(V)	13. to disapprove	to hate*	to detest*
(V)	14. to shine*	to scrub	to polish*
(N)	15. bathtub	pail*	bucket*
(V)	16. to prepare	to construct*	to build*
(N)	17. lawyer*	policeman	attorney*
(N)	18. omelet	pancake*	flapjack*
(V)	19. to propose*	to suggest*	to insist
(N)	20. dock*	pier*	shore
(V)	21. to brag*	to flatter	to boast*
(N)	22. axe*	hatchet*	razor
(N)	23. couch*	table	sofa*
(V)	24. to remember*	to review	to recall*
(V)	25. to scare*	to frighten*	to annoy
(V)	26. to continue	to start*	to begin*

Items omitted:

(N)	trailer	trolley*	streetcar*
(N)	hydrant	faucet*	spigot*
(N)	coat	pants*	slacks*
(N)	briefcase	wallet*	billfold*

Note: * indicates target items

Appendix V **Experiment 1 target and substitute pairs - semantic, visual and TOTs - with frequency and semantic relatedness ratings. Unrelated responses and perseverations are not included.**

P	T	TW	Freq	Im	Sub	Freq	Im.	Sem-rel
S14	VS	banjo	1	N.A.	guitar	2	N.A.	3.571
S9	VS	bear	24	5.72	wolf	9	6.10	2.92
S13	SC	bus	42	N.A.	van	2	5.72	3.142
S17	VS	crab	2	N.A.	elephant	18	6.16	2.071
S13	V	crown	19	6.02	fence	46	6.11	1.142
S17	V	crown	19	6.02	hair	160	5.80	3.142
S13	VS	goat	8	5.85	bullock	N.A.	N.A.	2.714
S12	VS	goat	8	5.85	cow	46	6.32	3.5
S13	VS	goat	8	5.85	cow	46	6.32	3.5
S8	VS	goat	8	5.85	deer	13	6.24	2.785
S2	TR	goat	8	5.85	dog	147	6.36	2.928
S2	TR	goat	8	5.85	donkey	1	N.A.	3.214
S2	TR	goat	8	5.85	horse	203	6.24	3.142
S22	V	leash/lead	4	N.A.	horseshoe	N.A.	N.A.	1.214
S10	V	leash/lead	4	N.A.	rope	19	5.96	3.142
S9	V	leashlead	4	N.A.	pair of clippers	N.A.		1.000
S14	V	leash/lead	4	N.A.	saddle	26	5.78	1.5
S2	TWC	money	275	6.04	crockery	N.A.	N.A.	1.142
S2	V	money	275	6.04	plates	44	5.27	1.357
S8	V	money	275	6.04	plates	44	5.27	1.357
S12	V	money	275	6.04	saucers	2	N.A.	1.214
S3	SA	money	275	6.04	sovereigns	16	N.A.	3.857
S8	V	money	275	6.04	trays	21	5.50	1.000
S1	SV	octopus	1	N.A.	crab	2	N.A.	3.428
S2	SV	octopus	1	N.A.	crab	2	N.A.	3.428
S9	TR	octopus	1	N.A.	crab	2	N.A.	3.428
S14	V	octopus	1	N.A.	face	379	5.81	1.000
S1	TR	octopus	1	N.A.	lobster	1	6.30	3.214
S3	SV	octopus	1	N.A.	man-o-war	N.A.	N.A.	2.714
S1	TR	octopus	1	N.A.	oyster	16	5.21	2.642
S17	SV	octopus	1	N.A.	spider	2	5.97	2.714
S2	SV	octopus	1	N.A.	toad	4	5.91	2.214
S2	SV	owl	6	5.95	parrot	2	N.A.	3.428
S9	TWC	owl	6	5.95	parrot	2	N.A.	3.428
S10	SV	owl	6	5.95	pigeon	5	6.10	3.142
S12	TWC	parrot	2	N.A.	bird	83	6.14	4.000
S13	SU	parrot	2	N.A.	bird	83	6.14	4.000
S22	SU	parrot	2	N.A.	bird	83	6.14	4.000
S3	SV	parrot	2	N.A.	bird of paradise	N.A	N.A.	3.285
S8	SC	parrot	2	N.A.	owl	6	5.95	3.214
S3	SV	parrot	2	N.A.	parakeet	1	N.A.	3.571
S6	TR	parrot	2	N.A.	Polly	N.A.	N.A.	2.214

Appendix V **Experiment 1 target and substitute pairs - semantic, visual and TOTs - with frequency and semantic relatedness ratings. Unrelated responses and perseverations are not included.**

P	T	TW	Freq	Im	Sub	Freq	Im.	Sem-rel
S14	VS	banjo	1	N.A.	guitar	2	N.A.	3.571
S9	VS	bear	24	5.72	wolf	9	6.10	2.92
S13	SC	bus	42	N.A.	van	2	5.72	3.142
S17	VS	crab	2	N.A.	elephant	18	6.16	2.071
S13	V	crown	19	6.02	fence	46	6.11	1.142
S17	V	crown	19	6.02	hair	160	5.80	3.142
S13	VS	goat	8	5.85	bullock	N.A.	N.A.	2.714
S12	VS	goat	8	5.85	cow	46	6.32	3.5
S13	VS	goat	8	5.85	cow	46	6.32	3.5
S8	VS	goat	8	5.85	deer	13	6.24	2.785
S2	TR	goat	8	5.85	dog	147	6.36	2.928
S2	TR	goat	8	5.85	donkey	1	N.A.	3.214
S2	TR	goat	8	5.85	horse	203	6.24	3.142
S22	V	leash/lead	4	N.A.	horseshoe	N.A.	N.A.	1.214
S10	V	leash/lead	4	N.A.	rope	19	5.96	3.142
S9	V	leashlead	4	N.A.	pair of clippers	N.A.		1.000
S14	V	leash/lead	4	N.A.	saddle	26	5.78	1.5
S2	TWC	money	275	6.04	crockery	N.A.	N.A.	1.142
S2	V	money	275	6.04	plates	44	5.27	1.357
S8	V	money	275	6.04	plates	44	5.27	1.357
S12	V	money	275	6.04	saucers	2	N.A.	1.214
S3	SA	money	275	6.04	sovereigns	16	N.A.	3.857
S8	V	money	275	6.04	trays	21	5.50	1.000
S1	SV	octopus	1	N.A.	crab	2	N.A.	3.428
S2	SV	octopus	1	N.A.	crab	2	N.A.	3.428
S9	TR	octopus	1	N.A.	crab	2	N.A.	3.428
S14	V	octopus	1	N.A.	face	379	5.81	1.000
S1	TR	octopus	1	N.A.	lobster	1	6.30	3.214
S3	SV	octopus	1	N.A.	man-o-war	N.A.	N.A.	2.714
S1	TR	octopus	1	N.A.	oyster	16	5.21	2.642
S17	SV	octopus	1	N.A.	spider	2	5.97	2.714
S2	SV	octopus	1	N.A.	toad	4	5.91	2.214
S2	SV	owl	6	5.95	parrot	2	N.A.	3.428
S9	TWC	owl	6	5.95	parrot	2	N.A.	3.428
S10	SV	owl	6	5.95	pigeon	5	6.10	3.142
S12	TWC	parrot	2	N.A.	bird	83	6.14	4.000
S13	SU	parrot	2	N.A.	bird	83	6.14	4.000
S22	SU	parrot	2	N.A.	bird	83	6.14	4.000
S3	SV	parrot	2	N.A.	bird of paradise	N.A	N.A.	3.285
S8	SC	parrot	2	N.A.	owl	6	5.95	3.214
S3	SV	parrot	2	N.A.	parakeet	1	N.A.	3.571
S6	TR	parrot	2	N.A.	Polly	N.A.	N.A.	2.214

S6	TR	parrot	2	N.A.	polyanthus	N.A.	N.A.	1.071
S8	TU	peacock	2	N.A.	bird	83	6.14	4.000
S6	TU	peacock	2	N.A.	bird	83	6.14	4.000
S12	V	peacock	2	N.A.	flower	78	6.18	1.285
S9	SV	peacock	2	N.A.	pheasant	3	N.A.	3.571
S22	V	road	262	6.09	dragonfly	N.A.	N.A.	1.000
S9	V	road	262	6.09	gnat	N.A.	N.A.	1.000
S3	V	road	262	6.09	hill	119	6.07	2.214
S3	V	road	262	6.09	leaf	33	6.08	1.000
S2	TWC	steak/chop	14	6.47	beef	32	6.25	3.785
S8	SC	steak/chop	14	6.47	beef	32	6.25	3.785
S8	TWC	steak/chop	14	6.47	lamb	14	6.14	3.412
S2	SV	steak/chop	14	6.47	meat	57	6.18	3.857
S9	SU	steak/chop	14	6.47	meat	57	6.18	3.857
S12	SU	steak/chop	14	6.47	meat	57	6.18	3.857
S14	SA	steak/chop	14	6.47	mutton	8	4.84	2.928
S14	SA	steak/chop	14	6.47	pig	14	6.35	2.142
S22	V	steak/chop	14	6.47	sole	7	4.62	2.142
S12	V	strawberry	2	N.A.	rose	18	6.23	1.214
S12	V	strawberry	2	N.A.	sweet	2	4.93	2.428
S17	TWC	table	242	5.82	stool	8	5.84	3.285
S2	SV	table	242	5.82	stool	8	5.84	3.285
S9	SA	tie	27	5.51	collar	14	5.82	3.857
S13	SA	tie	27	5.51	collar	14	5.82	3.857
S2	TWC	tie	27	5.51	collar	14	5.82	3.857
S9	SA	tie	27	5.51	shirt	29	6.12	3.214
S13	SA	tie	27	5.51	shirt	29	6.12	3.214
S14	SC	trombone	N.A..	N.A.	banjo	1	N.A.	2.214
S10	TU	trombone	N.A.	N.A.	bugle	N.A.	N.A.	3.571
S2	TR	trombone	N.A.	N.A.	horn	33	5.66	3.214
S1	SV	trombone	N.A.	N.A.	saxophone	4	6.02	3.357
S9	SC	trombone	N.A.	N.A.	trumpet	6	6.28	3.571
S2	SC	trombone	N.A.	N.A.	trumpet	6	6.28	3.571
S8	SC	trombone	N.A.	N.A.	trumpet	6	6.28	3.571
S12	SC	trombone	N.A.	N.A.	trumpet	6	6.28	3.571
S3	SC	wheelbarrow	N.A.	N.A.	weedcart	N.A.	N.A.	3.357

Key: P = participant; T = type of error; TW = target word; Freq = frequency; Im = imageability; Sub = substitute rel = semantic relatedness rating; N.A. = no rating available.

Error types: TWc = target within circumlocution; TR = resolved TOT; TU = unresolved TOT; V = visual; SV = ambiguous visual/semantic; SC = semantic co-ordinate; SU = superordinate; SA = semantic associate.

Appendix VI TOT 1 Target words and definitions with frequencies (per million in parentheses)

High frequency

butter (2)	An edible fat made from churned cream which you use spread on bread
brush (36)	Thing made of bristles set in wood used for hair, shoes or fingernails
chair (89)	A piece of furniture for sitting on at a table
cup (58)	A piece of china for drinking tea out of
egg (47)	It has a yolk and a white and is laid by birds
garage (25)	A building for keeping cars in
gold (37)	Yellow-coloured precious metal used for jewellery
library (90)	Building from which to borrow books
snake (70)	Reptile with no legs and a forked tongue that slithers about
tie (27)	Item of clothing worn knotted around a shirt collar
uncle (58)	Your father or mother's brother
watch (31)	Time-piece that is worn on the wrist

Low frequency

antler (3)	The large spiky horn of a stag or other deer
barber (5)	Man who cuts hair and gives shaves
botanist (3)	A person who scientifically studies plants
carrot (5)	Long orange vegetable that grows under the ground.
geography (5)	Study of the earth which uses maps and is taught in schools
glacier (2)	Slow-moving mass of ice found at the tops of mountains
mermaid (1)	Woman who lives in the sea and has a fishes tail
octopus (1)	A sea creature with eight tentacles
owl (6)	Large-eyed bird of prey that flies at night and hoots
raft (5)	A boat made from pieces of wood tied together
turkey (4)	A farmyard animal that gobbles and is eaten at Christmas
wizard (3)	A male witch who is said to perform magic, sorcery and conjuring

Appendix VII PRAD and control groups' target word and TOT relative pairs with mean semantic relatedness ratings from TOT 1. The figure in parentheses indicates how many times this response was given.

PRAD subjects' responses

antler - horn (2)	3.50
antler - reindeer	3.71
barber - hairdresser	3.86
botanist - farmer	2.07
botanist - gardener	3.64
botanist - geologist	2.50
botanist - ornithologist	2.64
carrot - cauliflower	3.57
carrot - potato	3.29
garage - shed	3.50
glacier - iceberg	3.93
glacier - icicles (2)	3.21
octopus - crab	3.43
octopus - crocodile (2)	2.64
octopus - lizard	2.21
octopus - ottoman	1.13
octopus - octopan	nonword
octopus - octoped	nonword
octopus - snake	2.57
owl - cuckoo (2)	3.29
owl - hawk	2.93
raft - paddle	3.14
raft - plank	2.21
uncle - brother-in-law	3.43
uncle - father-in-law	3.00
uncle - mother-in-law	3.00
uncle - sister-in-law	3.00
wizard - ghost	2.14
wizard - witch	3.64

Control subjects' responses

botanist - agriculturalist	2.92
botanist - biologist	3.14
botanist - entomologist	2.60
botanist - florist	2.64
geography - atlas	3.71
glacier - iceberg	3.93
mermaid - maid	2.00
raft - float	3.57
wizard - magician	3.79
wizard - Merlin	3.86
wizard - Warlock	3.54

<u>Appendix VIII</u> PRAD and control groups target word and own-target word pairs produced in TOT 1 with mean semantic relatedness ratings. The figure in parentheses indicates how many times this response was given if more than once.

<u>PRAD group</u>

antler - porcupine	1.50
barber - enthusiastic worker	1.71
barber - hairdresser	3.86
botanist - gardener (4)	3.64
botanist - scientist	3.57
butter - margarine (2)	3.86
carrot - marrow	3.50
carrot - potato	3.29
carrot - spuds	3.36
garage - parking place	3.21
geography - areas	3.43
geography - maps	3.79
glacier - frozen	3.14
glacier - iceberg (2)	3.93
glacier - rocks	3.21
gold - platinum	3.64
gold - silver	3.64
mermaid - sailor's wife	2.15
mermaid - swimmer	2.86
octopus - lobster	3.21
octopus - big fish	2.86
owl - swans	3.07
raft - fishing-boat	3.14
raft - rafter	2.15
raft - risky	1.07
snake - fish	2.57
tie - pullover	3.14
tie - scarf	3.58
tie - terylene	1.64
turkey - goose	3.29

turkey - greedy animal	1.93
uncle - William	1.50
uncle - stepfather	3.14
wizard - bitch	1.21
wizard - comedian	2.29
wizard - conjuror	3.79

Control group

barber - hairdresser (2)	3.86
botanist - gardener (4)	3.64
botanist - horticulturalist (2)	3.60
butter - cheese	3.79
glacier - iceberg (2)	3.93
snake - adder	3.93
tie - shirt	3.21
turkey - goose	3.29
uncle - in-law	2.86
wizard - conjuror	3.79
wizard - magician	3.79

Appendix IX PRAD and control groups target word and constructive search word pairs produced in TOT 1with mean semantic relatedness ratings. The figure in parentheses indicates how many times this response was given.

PRAD group

antler - animal	3.14
antler - cavalier	1.21
antler - collars	1.64
antler - crown	2.29
antler - elephant	2.21
antler - feathers	1.71
antler - fur	2.07
barber - farmer	1.64
botanist - gardener	3.64
botanist - head gardener	3.71
botanist - specialist	3.07
brush - grease	1.86
brush - oil	1.93
butter - cheese (2)	3.79
butter - crumbs	2.64
butter - fats	3.29
butter - jam	3.21
butter - lard	3.86
butter - meaty	1.14
butter - spread	3.64
butter - tomatoes	2.50
carrot - apple	3.14
chair - cushion	3.54
cup - coffee-pot	3.21
cup - teapot	3.57
cup - wineglass	3.71
geography - arithmetic	3.00
geography - composition	1.93
geography - history	3.07
geography - map-finding	3.07

geography - map-reading	3.14
geography - teacher	3.57
glacier - iceberg	3.93
glacier - temperature	2.64
glacier - weather	2.21
gold - bracelets	3.12
gold - brass	3.57
gold - carats	4.00
gold - ring (2)	3.43
owl - cuckoo	3.29
owl - dove	3.21
owl -eagle	3.50
raft - barge	3.21
snake - worm	3.07
turkey - chickens	3.21
turkey - cockerels	3.29
turkey - dog	2.14
turkey - goose	3.29
turkey - mincemeat	2.21
turkey - mistletoe	2.14
turkey - mouse	2.21
turkey - rat	2.14
uncle - cousin	3.57
uncle - relative (2)	3.71
watch - clock	3.86
wizard - actor (2)	1.71
wizard - actress	1.36
wizard - gentleman	1.86

<u>Control group</u>

barber - hairdresser	3.86
butter - cheese (2)	3.79
butter - yoghurt	3.14
carrot - marrow	3.50
carrot - parsnip	3.50
carrot - potato (2)	3.29
carrot - swede	3.57

carrot - turnip	3.43
geography - archaeology	2.64
geography - globe	3.64
geography - history	3.07
glacier - iceberg (3)	3.93
glacier - ice-floe	3.71
glacier - icicles	3.07
raft - canoe	3.43
raft - catamaran	3.32
raft - sampan	3.60
tie - scarf (2)	3.58
turkey - goose (2)	3.29
uncle - nephew	3.71
wizard - conjuror	3.79
wizard - magician	3.79

Appendix X **All responses produced in Experiment 3, category fluency task.**

Appropriate responses are marked with a '*'.

PRAD group

	Vehicles	Clothing	Furniture	Instruments
S1	1. Ford car* 2. mower* for the garden 3. bikes* 4. walking 5. shop-viewing	1. dresses* 2. coat* 3. shoes* 4. boots* 5. dressing gown* 6. nightdresses*	1. chair* 2. table* 3. stool* 4. dressing table* 5. clock* 6. t.v.*	1. piano* 2. trumpet* 3. the orchestra*
S2	1. car* 2. van* 3. lorry* 4. bicyicle* 5. did I say bicycle? 6. lorry 7. bicycle 8. van 9. bicycle	1. coat* 2. dress* 3. petticoat* 4. knickers* 5. hat* 6. tights* 7. petticoat 8. pantaloons* 9. pants*	1. chair* 2. table* 3. sideboard* 4. chair	1. piano* 2. violin*
S3	1. van* 2. Abraham daughter and sons 3. saloon* 4. motorcycles*		1. chairs* 2. armchair*	1. end motors 2. bagpipes* 3. trumpet*
S4	1. Rover* 2. taxi* 3. bus* 4. horse & cart* 5. horse* 6. racehorses* 7. brooms and brushes 8. pans 9. dustpans	1. vest* 2. sundries like knickers* 3. petticoat * 4. suspender belt*	1. sofa* 2. bureau* 3. handmachine for sewing* 4. chairs* 5. table* 6. dining table* 7. carpet* 8. paraphernalia in front of the fire 9.Hoover*	1. fiddle* 2. violin* 3. fiddle 4. violin 5. banjo* 6. mouth organ* 7. piano*
S5	1. motorbike* 2. bicycle* 3. car* 4. train* 5. bus* 6. aeroplane* 7. motorbike 8. pushbike* 9. car 10. bus 11. tractor* 12. mowing machine*	1. macintosh* 2. overcoat* 3. dresses* 4. petticoats* 5. vests* 6. brassiere* 7. socks* 8. stockings* 9. slippers* 10. shoes* 11. wellingtons*	1. chair* 2. table* 3. settee* 4. stool* 5. rug* 6. mat* 7. bed*	1. piano* 2. violin* 3. fiddler 4. organ* 5. whistle* 6. drums* 7. organ 8. trumpet* 9. bells* 10.whistle 11. mouth organ*
S6	1. car* 2. trains*	1. dress* 2. coat*	1. bed* 2. table*	1. piano* 2. drums*

	3. car 4. bus* 5. charabanc* 6. bus 7. train 8. tram*	3. boots* 4. shoes* 5. vest* 6. dress 7. shoes 8. stockings* 9. slippers* 10. shoes 11. these (indicating own footwear)	3. piano* 4. cups 5. saucers 6. milkjug 7. piano 8. bed	3. violin* 4. pram 5. fiddle* 6. piano 7. violin
S7	1. cars*	1. plain suits* different colours	1. solid 2. rather flimsy	1. piano*
S8	1. car*	1. dresses*		1. piano*
S9	1. car*			1. banjo*
S10	1. car* 2. motorbike* 3. bicycle* 4. car 5. car 6. motorbike or what? 7. bicycle 8. car 9. motorbike 10. bicycle or what do you call them?	1. trousers* 2. jacket* 3. coat* 4. trousers 5. trousers 6. socks* 7. shoes*	1. settee* 2. armchairs*	1. violin* 2. violin 3. guitar*
S11	1. cars* 2. lorries* 3. tractors* 4. big lorries 5. railways 6. airports with the planes* 7. ships* that go across the sea 8. big clock in the town 9. big containers that carry things	1. furcoat* 2. coat* 3. tweed suits* 4. ballgowns* 5. dress* 6. shoes* 7. stockings* 8. petticoats* 9. nightwear* 10. suits* for ladies 11. ballgowns 12. suits 13. overcoats* 14. trilbys* 15. shoes	1. chairs* 2. tables* 3. sideboard* 4. settees* 5. easychairs* 6. mirrors* 7. pictures* 8. fireplaces* 9. doors* 10.sideboard have I said that? 11. settees and things like that 12. and pictures 13. windows* 14. lights* 15. chandeliers* 16. carpets* 17. rugs*	1. piano* 2. violin* 3. radio 4. trumpets* 5. pipes* 6. saxophones* 7. pianos 8. trumpets 9. violins
S13	1. car* 2. cart*	1. hats*	1. chair*	
S17				1. pianists 2. piano*
S20	1. cars* 2. motorbikes*	1. jumper* 2. blouse* 3. buttons	1. chairs* 2. tables* 3. mats 4. tablemats 5. eggs 6. buckets	1. piano* 2. violin* 3. drums* 4. drums 5. drums 6. drums

S21	1. car* 2. shop - no that's not it 3. car 4. big lorry*	1. dress* 2. piece of dress 3. pair of shoes* 4. pair of socks* 5. pair of nice underwear*	1. fruit 2. plums in the kitchen 3. oranges 4. apples 5. eggs 6. onions	1. blow 2. blow 3. kettle 4. kennel 5. not a kennel that's a dog

CONTROLS

C1	1. car* 2. lorry* 3. train* 4. bus* 5. horse & cart* 6. horse & trap* 7. horse & sidecar 8. bicycle* 9. motorbike* 10. pushbike* 11. taxi*	1. shoes* 2. socks* 3. trousers* 4. pullover* 5. teeshirt* 6. shirt* 7. overcoat* 8. raincoat* 9. jacket* 10. stockings* 11. petticoat* 12. corset* 13. suspender belt* 14. vest* 15. long johns* 16. bloomers*	1. table* 2. chair* 3. settee* 4. bookcase* 5. sewing machine* 6. desk* 7. bed*	1. accordion* 2. fiddle* 3. violin* 4. drum* 5. clarinet* 6. pipe*
C2	1. cars* 2. buses* 3. train* 4. lorry* 5. truck* 6. juggernauts* 7. motorbike* 8. bicycle* 9. pram* 10. wheelchair*	1. vest* 2. pants* 3. slips* 4. dress* 5. cardigan* 6. coat* 7. jumpers* 8. skirts* 9. hat* 10. scarves* 11. nightdress* 12. socks* 13. stockings* 14. slippers* 15. dressing gown*	1. chairs* 2. table* 3. cabinets* 4. sideboards* 5. t.v.* 6. bed* 7. wardrobe* 8. chairs - oh I said that	1. piano* 2. organ* 3. violin* 4. oboe* 5. banjo* 6. saxophone* 7. clarinet* 8. trumpet* 9. said sax didn't I 10. guitar* 11. drums* 12. ukelele*
C3	1. car* 2. lorry* 3. cycle* 4. have I said lorry? 5. van* 6. juggernaut*	1. coat* 2. blouse* 3. skirt* 4. dress* 5. underwear* 6. tights* 7. waistcoat* 8. jacket* 9. overcoat* 10. hat* 11. scarf*	1. table* 2. chair* 3. coffeetable* 4. nest of tables* 5. suite* 6. t.v.* 7. dressing table* 8. wardrobe* 9. tallboy* 10. dressing stool* 11. bedside tables* 12. cabinet* 13. trolleys*	1. banjo* 2. piano* 3. organ* 4. flute* 5. harp* 6. violin* 7. ukelele*
C4	1. cars* 2. lorries* 3. tractors* 4. motorbikes* 5. steam engines*	1. pullover* 2. trousers* 3. socks* 4. vest* 5. shirt*	1. television* 2. wireless* 3. settee* 4. armchair* 5. sideboard*	1. banjo* 2. mandolin* 3. guitar* 4. Hawaiian guitar* 5. saxophone*

6. pushbikes*
7. buses*
8. taxis*
9. caravans*

6. skirt*
7. blouse*
8. briefs*
9. panties*
10. bras*
11. nightdresses*
12. under slips*
13. shoes*
14. slippers*
15. gloves*
16. overcoat*
17. macintosh*
18. cape*
19. jeans*
20. tights*
21. jacket*
22. vest
23. waistcoat*

6. table*
7. dining table chairs*
8. side tables*
9. table lamps*
10. stools*
11. occasional tables*
12. bed*
13. dressing table*
14. wardrobe*
15. bedside table*
16. bedside lamp*
17. bureau*
18. tea trolley*
19. wall cupboards*
20. firescreen*
21. record player*
22. paper rack*

6. clarinet*
7. cornet*
8. trumpet*
9. oboe*
10. buffoon or something
11. drums*
12. castanets8
13. violins*
14.piano accordion*
15. piano*
16. cymbals*
17. trombone*
18. flute*
19. harpsichord*
20. harp*
21. ukelele*

Appendix XI **Items produced by less than 10% of subjects in Experiment 3, category fluency, and therefore judged to be atypical. Associative frequencies (AF) of 44 or less (Battig & Montague, 1969) and 7 or less (Hampton & Gardiner, 1983) with number of instances in parentheses*.**

Item	Battig & Montague AF	Hampton & Gardiner AF
horse (1P)	14	7
juggernaut (2C)	0	4
mower (1P)	3	0
pram (1C)	0	3
pushbike (1P, 2C)	0	7
wheelchair (1C)	1	0
bloomers (1C)	1	0
brassiere** (1P)	0	0
cape (1C)	3	0
corset (1C)	1	2
overcoat (2P, 3C)	20	6
panties (1C)	14	0
raincoat (1C)	15	4
slippers (2P, 2C)	1	1
clock (1P)	3	0
doors (1P)	1	0
easychair (1P)	5	0
lights (1P)	3	0
record player (1C)	4	0
sewing machine (1C)	3	0
side tables (1C)	2	0
tallboy ((1C)	0	4
trolley (1C)	0	1
accordion (1C)	37	
bells (1P)	10	
castanets (1C)	2	
cornet (1C)	33	

cymbals (1C)	43
fiddle (1C)	20
harpsichord (1C)	20
mandolin (1C)	6
pipes (1P, 1C)	1
ukelele (3C)	15

* P = PRAD   C = control

**appears in typicality and familiarity ratings in H&G but was not generated in either set of norms.

<u>Appendix XII</u> Items generated in Experiment 3, category fluency, that do not occur in either the Battig and Montague (1969) or the Hampton and Gardiner (1983) norms.

PRAD	Control
charabanc	caravan
horse and cart	horse and cart
mowing machine	horse and trap
racehorses	steam engines
Rover	
saloon	
ballgowns	dressing gown
dressing gown	long johns
fur coat	nightdress (2)
nightdresses	suspender belt
nightwear	underslips
pantaloons	
suspender belt	
trilbys	
tweed suits	
wellingtons	
chandeliers	bedside lamp
dining table	dining table chairs
fireplaces	dressing stool
Hoover	firescreen
hand machine for sewing	nest of tables
mat	occasional tables
windows	paper rack
	suite
	tea trolley
	wall cupboards
	wireless
bagpipes	Hawaiian guitar
mouth organ (2)	piano accordian
whistle	

<u>Appendix XIII</u> Items generated in Experiment 3, category fluency task, by less than 10% of subjects in one set of norms (AF 44 or less, Battig & Montague, 1969; 7 or less, Hampton & Gardiner, 1983) but more in the other set.

Item	Battig & Montague AF n = 442	Hampton & Gardiner AF n = 72
tram (1P*)	2	18
jeans (1C*)	2	17
jumper (1P, 1C)	13	44
Mackintosh (1P, 1C)	0	11
trousers (1P, 2C)	41	55
vest (2P, 2C)	29	25
waistcoat (2C)	0	15
armchairs (2P, 1C)	3	22
bedside table (1C)	0	8
carpet (2P)	1	17
coffee-table ((1C)	44	13
settee (3P, 2C)	3	23
sideboard (2P, 2C)	1	23

* P = PRAD   C = control

<u>Appendix XIV</u> Experiment 4 naming task target and substitute pairs - semantic, visual and TOTs - with frequency and semantic relatedness ratings. Unrelated and perseverations not included.

P	T	TW	Freq	IM	Sub	Freq	IM	semrel
S6	V	apron	8	5.65	bag	51	5.70	1.571
S5	SU	barge	8	N.A.	boat	123	6.31	3.357
S2	TWC	barge	8	N.A.	boat	123	6.31	3.357
S1	V	barge	8	N.A.	countryside	7	N.A.	2.214
S5	SU	barge	8	N.A.	ship	126	6.12	3.071
S4	V	barge	8	N.A.	walk	40	5.05	1.214
S1	SV	bath	31	6.01	sink	12	5.99	3.571
S4	SV	bath	31	6.01	sink	12	5.99	3.571
S6	V	cap	22	N.A.	apple	15	6.37	1.000
S2	TWC	cap	22	N.A.	hat	71	5.62	4.000
S3	SCI	cap	22	N.A.	hat	71	5.62	4.000
S4	TWC	cap	22	N.A.	heart	199	6.17	1.000
S6	V	cap	22	N.A.	potato	30	6.17	1.071
S4	V	castanets	1	N.A.	bag	51	5.70	1.071
S2	V	castanets	1	N.A.	bellows	3	N.A.	1.357
S3	V	castanets	1	N.A.	cherries	6	5.82	1.000
S4	V	castanets	1	N.A.	onion	19	6.17	1.000
S2	TU	coach	30	5.60	charabang	N.A.		2.357
S1	TWC	coach	30	5.60	lorry	N.A.		3.214
S1	SA	hammock	5	N.A.	swing	13	N.A.	3.461
S2	SA	hammock	5	N.A.	swing	13	N.A.	3.461
S4	TR	hammock	5	N.A.	swing	13	N.A.	3.461
S5	SA	hammock	5	N.A.	swing	13	N.A.	3.461
S6	SC	recorder	7	N.A.	bugle	2	N.A.	3.142
S3	SV	recorder	7	N.A.	flute	1	5.81	3.285
S5	SV	recorder	7	N.A.	flute	1	5.81	3.285
S4	V	recorder	7	N.A.	pencil	38	6.07	1.5
S5	SC	recorder	7	N.A.	trumpet	6	6.28	3.214
S1	SV	recorder	7	N.A.	whistle	3	5.74	3.071
S5	SV	recorder	7	N.A.	whistle	3	5.74	3.0715
S6	V	rocket	22	6.12	candle	23	5.94	1.5
S3	V	rocket	22	6.12	chimney	10	N.A.	1.357
S1	V	rocket	22	6.12	pen	18	5.76	1.357
S4	V	rocket	22	6.12	pencil	38	6.07	1.214
S5	V	rocket	22	6.12	trumpet	6	6.28	1.000
S5	V	rocket	22	6.12	umbrella	11	5.92	1.214
S4	SA	sofa	9	5.97	Chesterfield	N.A.	N.A.	2.692
S5	SV	tambourine	2	N.A.	drum	26	5.99	3.307
S2	TR	tambourine	2	N.A.	tombola	N.A.	N.A.	1.5
S4	SV	trumpet	6	6.28	bugle	2	N.A.	3.642

S6	TU	trumpet	6	6.28	bugle	2	N.A.	3.642
S4	SV	van	2	5.72	ambulance	7	6.27	2.857
S1	SU	van	2	5.72	car	393	6.38	3.428
S2	SC	van	2	5.72	coach	30	5.60	3.285
S5	SC	van	2	5.72	coach	30	5.60	3.285
S5	SC	van	2	5.72	lorry	N.A.	N.A.	3.571
S5	SC	van	2	5.72	taxi	19	N.A.	2.928
S3	SV	violin	13	6.06	viola	N.A.	N.A.	3.642

Key: T = type of error; TW = target word; Freq = frequency; Im = imageability; Sub = substitute; Sem-rel = semantic relatedness rating; N.A. = no rating available.

Error types: TWc = target within circumlocution; TR = resolved TOT; TU = unresolved TOT; V = visual; SV = ambiguous visual/semantic; SC = semantic co-ordinate; SU = superordinate; SA = semantic associate; SCI = semantic circumlocutory; NA - no rating available.

<u>Appendix XV</u> Experiment 5 target words and definitions with frequencies (per million, in parentheses).

Barge	Vehicle used on canals for transporting goods and passengers.
Trumpet	Brass musical instrument with three stops and a flared end used by the cavalry.
Shirt	Item of clothing with collar worn by men under jackets.
Bath	Household fixture for holding water to immerse and wash body in.
Tambourine	Small circular musical instrument with jangling metal discs that is tapped or banged.
Van	Small commercial vehicle for transporting goods by road.
Cap	Head - covering usually round with a peak worn by schoolboys.
Chair	Item of furniture for sitting on at a table.
Violin	Musical instrument with four strings that is tucked under the chin and played with a bow.
Apron	Garment to cover the front of a person's clothes which is tied at the back.
Curtains	Two pieces of cloth hung either side of a window which are drawn to form a screen.
Car	Small vehicle with four wheels for private motoring.
Wardrobe	Household cupboard with hangers for storing clothes.
Turban	Male head dress of long scarf wound around head for religious or cultural reasons.
Piano	Musical instrument found in orchestras and houses played by pressingblack and white keys.
Rocket	Vehicle for travelling into space propelled by the ignition of its contents.
Castanets	Wooden musical instrument which is clicked between the fingers to accompany Spanish dancing.
Coach	Vehicle used for touring holidays and long journeys by road
Dress	Female item of clothing where bodice and skirt are attached to form one piece.
Sofa	Item of furniture for several to sit on with raised back and ends.
Trousers	Garment with two legs for covering from waist to ankles.
Train	V ehicle comprising series of railway carriages drawn by the same engine.
Recorder	A woodwind instrument that is blown through the end and is popular in schools.
Hammock	A canvas bed suspended by cords at the ends.

Appendix XVI **Targets and relatives produced in a TOT state in Experiment 5.**

s	rt	TW	Freq	IM	Rel.	Freq	IM	sr	wc
5	TR	apron	8	5.65	dressing gown	N.A.	NA	2.714	n
1	TU	coach	30	5.60	bus	42	6.38	3.714	n
1	TU	coach	30	5.60	car	393	NA	3.142	n
1	TU	coach	30	5.60	charabanc	N.A.	NA	2.375	n
1	TU	coach	30	5.60	van	2	5.72	3.5	n
6	TR	curtains	21	NA	cloth	43	5.47	1.857	n
1	TU	hammock	5	NA	chair	89	6.10	2.214	n
2	TR	hammock	5	NA	hassock	N.A.	NA	1.4	n
4	TU	hammock	5	NA	swing	13	NA	3.461	n
1	TU	hammock	5	NA	swing	13	NA	3.461	n
2	TR	hammock	5	NA	tent	30	5.93	2.428	n
2	TR	recorder	7	NA	horn	33	5.66	3.214	n
3	TU	trumpet	6	6.28	tambourine	2	NA	3.071	n
4	TR	van	2	5.72	bus	42	NA	3.142	n
5	TR	wardobe	8	NA	clothes	89	NA	2.928	n
5	TR	wardrobe	8	NA	cupboard	4	NA	3.5	n
5	TR	wardrobe	8	NA	sideboard	2	NA	3.00	n

Key:
s = subject; rt = response type; TW = target; Freq. = frequency; IM = imageabilty; Rel. = relative; sr = semantic relatedness rating; wc = word class; N.A. = no rating available.

Appendix XVII Targets and own target words produced in Experiment 5.

S	TW	Freq.	IM	OTW	Freq.	IM	Sr	wc
5	barge	8	N.A.	boat	123	6.31	3.357	n
4	barge	8	N.A.	boats	123	6.31	3.357	n
6	barge	8	N.A.	steamboat	3	N.A.	3.357	n
7	car	393	6.38	Mini	N.A.	N.A.	3.928	pn
3	car	393	6.38	sidecar	N.A.	N.A.	3.142	n
4	castanets	1	N.A.	banjo	1	N.A.	2.642	n
5	castanets	1	N.A.	Rock & Roll	3	N.A.	1.857	n
1	castanets	1	N.A.	violin	13	6.06	2.428	n
3	chair	89	6.10	sideboard	2	N.A.	2.928	n
4	coach	30	5.60	omnibus	N.A.	N.A.	2.428	n
3	curtains	21	N.A.	pillow	11	6.24	2.21	n
5	dress	63	5.95	laundry	5	5.59	2.571	n
1	dress	63	5.95	slip	N.A.	4.97	3.642	n
3	dress	63	5.95	tunic	1	5.08	3.571	n
7	piano	29	6.30	violin	13	6.06	3.071	n
6	recorder	7	N.A.	pipe	N.A.	5.98	3.428	n
1	recorder	7	N.A.	trumpet	6	6.28	3.214	n
4	rocket	22	6.12	aeroplane	N.A.	N.A.	3.214	n
1	rocket	22	6.12	plane	138	5.56	3.214	n
5	shirt	29	6.12	evening clothes	N.A.	N.A.	3.214	n
3	shirt	29	6.12	helmet	3	6.20	1.714	n
8	shirt	29	6.12	pockets	59	5.58	3.142	n
6	tambourine	2	N.A.	drum	26	5.99	3.307	n
3	train	86	5.93	Pullman	3	N.A.	2.5	pn
7	train	86	5.93	tank engine	N.A.	N.A.	3.571	n
4	trousers	10	N.A.	gown	18	5.78	2.642	n
7	trousers	10	N.A.	table	242	5.82	1.00	n
3	trumpet	6	6.28	squad	20	N.A.	1.071	n
7	turban	2	N.A.	confirmation	7	N.A.	1.142	n
3	van	2	5.72	barrow	N.A.	N.A.	2.00	n
1	van	2	5.72	car	393	6.38	3.428	n
5	van	2	5.72	bicycles	7	6.38	2.142	n

Key:
s = subject; TW = target; Freq. = frequency; IM = imageabilty; OTW = own target word; sr = semantic relatedness rating; wc = word class; N.A. = no rating available.

Appendix XVIII **Targets and constructive search words produced in Experiment 5.**

S	TW	Freq	IM	CS	Freq	IM	sr	wc
3	apron	8	5.65	waterproof	NA		1.642	n
7	barge	8		boat	123	6.31	3.357	n
7	barge	8		ferry	12	5.92	3.571	n
3	bath	31	6.01	duvet	N.A.		1.428	n
5	bath	31	6.01	river	183	6.33	2.571	n
3	bath	31	6.01	sponge	6	5.77	3.5	n
5	bath	31	6.01	swimming baths	N.A.		3.142	n
5	bath	31	6.01	swimming pool	N.A.		3.214	n
5	car	393	6.38	pram	2		1.928	n
5	car	393	6.38	pushchair	N.A.		2.071	n
8	chair	89	6.10	stool	8	5.84	3.857	n
5	coach	30	5.60	racing car	N.A.		2.642	n
8	coach	30	5.60	train	86	5.93	2.428	n
5	curtains	21		cloth	43	5.47	1.857	n
5	curtains	21		duster	N.A.		1.928	n
5	hammock	5		bedclothes	N.A.		2.5	n
5	hammock	5		pillows	11	6.24	2.714	n
5	hammock	5		sheets	71	5.94	3.571	n
4	recorder	26		turban	2		1.00	n
7	recorder	26		violin	13	6.06	3.0	n
5	rocket	22	6.12	car	393	6.38	1.642	n
5	rocket	22	6.12	motorbike	N.A.		1.571	n
5	rocket	22	6.12	pushbike	N.A.		1.428	n
3	tambourine	2		cymbal	N.A.		3.357	n
3	tambourine	2		Cymbeline			1.00	pn
5	tambourine	2		violin	13	6.06	3.857	n
5	train	86	5.93	station	195	5.54	3.214	n
8	trousers	10		skirt	22	5.73	3.785	n
2	trousers	10		slip	19	4.97	1.785	n
2	trumpet	6	6.28	bugle	2		3.642	n
3	turban	2		loofah	N.A.		1.00	n
3	wardrobe	8		cabinet	22	5.24	3.142	n
3	wardrobe	8		clothes	89		2.928	n
3	wardrobe	8		cupboard	4		3.5	n

Key: s = subject; TW = target; Freq. = frequency; IM = imageabilty; CS = constructive search word; sr = semantic relatedness rating; wc = word class; N.A. = no rating available.

<u>Appendix XIX</u> PRAD definitions in Experiment 7 rated at less than 0.5, with targets and semantic relatedness ratings.

target	participant		rating
bath	S1	Is a .... Where you get a .... In most houses and use it daily.	0.375
rocket	S1	Is a mechanical instrument that is used outdoors.	0
castanets	S1	Oh I can't. Don't know what they are.	0
shirt	S2	Man's next to his body. No it isn't. Might be next to his body.	0.25
recorder	S3	Date ... is for the purpose of showing when a piece of filing is dated.	0.125
van	S4	Cigarette.	0
rocket	S5	To swing in.	0
castanets	S5	Sort of a curtain aren't they?	0
dress	S5	Wear.	0.375
recorder	S5	Printer or something like that.	0
tambourine	S6	Thing that you...they have bang sometimes.	0.125
hammockq	S6	I don't think I could tell you.	0
van	S7	Used by bakers and people who sell bread and all that sort of thing.	0.25
cap	S7	If you're out hunting you have to wear a	0.25
chair	S7	If you were going to. If you're the..., you're the head.	0.125
violin	S7	It's got a long arm really. Quite a big instrument.	0.25
rocket	S7	For shooting. For rabbits and those sorts of things.	0.125
dress	S7	Something like this but isn't really.	0
shirt	S10	No response (pulled own shirt).	0
castanets	S10	Can't remember	0
curtains	S11	All sorts of materials.	0.285
coach	S11	Used to have them in the old days. A bicycle takes you away on holidays.	0.2

<u>Appendix XX</u> Experiment 8 materials (not including definitions from TOT1 and TOT 2).

anachronism	something out of keeping with the times in which it exists.
eclectic	freely selecting from many different sources.
literate	able to read and write.
hypochondriac	a person unnecessarily anxious about their health.
liberty	freedom and right to do as one pleases.
gargle	mouth and throat wash.
abstemious	sparing, moderate, not self-indulgent, especially in food and drink.
worm	small, creeping, burrowing animal with no limbs.
diminuendo	a musical term for a passage performed with gradual decrease in loudness.
radio	apparatus for receiving sound messages through the airwaves.
cherubic	like a beautiful, angelic child.
squeal	shrill cry like a pig's from fear, pain or anger.
tranquilize	to make calm or serene or to reduce agitation, especially by use of a dru.
incubate	to keep eggs warm until hatching.
window	glass-filled opening in wall or roof of building, allowing in light and a view of the outside.
determinist	adherent to the view that human action is not free but directed by external forces acting on the will.
geology	scientific study of the world's crust and the layers of which it is composed.
iniquitous	term used to describe a decision or person which is wicked or grossly unfair.
agnostic	adherent to the view that whether God exists is unknown.
girdle	belt or cord used around the waist for support.
trousers	garment with two legs for covering from waist to ankles.
gosling	a young goose.
suspect	believe something to be true without adequate proof.
taciturn	saying little, reserved, uncommunicative.
hospice	house of rest for travellers or for the terminally ill, often kept by a religious order.
advent	season before Christmas marking the coming of Christ.
bibliophile	lover of books.
letter	written or printed message sent to a person, usually by pos.
alchemy	Medieval forerunner of Chemistry.
bilateral	of, on, or with two sides.
banshee	female spirit whose wailportends death.
fabric	woven, knitted or felted material.

Haemorrhage	the escape of blood from vessels, including internal as well as external bleeding.
jigsaw	puzzle in which one tries to piece together the a broken picture.
vacuous	hollow or, as regards people, unintelligent, expressionless.
decanter	stoppered glass vessel in which spirits are brought to the table.
cassock	long, close garment worn particularly by clergy and choristers, often under a surplus.
banal	obvious or trite.
television	apparatus with aerial for displaying moving visual images.
decrease	make less, diminish.
accordion	portable musical instrument with keyboard, buttons and bellows.
bemuse	to stupefy, bewilder or confuse.
idiomatic	referring to a phrase or way of expression natural or peculiar to particular language.
embryology	the study of the developing foetus before birth.
carcass	remains of a dead animal, especially at a butcher's.
malevolence	the desire to do evil, or for others to have ill fortune.
defaulter	someone who fails to act, to pay, or to appear for judgement in court.
negotiable	term describing an issue that is open to discussion or modification.
history	record of important past events and people.
omnivorous	feeding on both plants and flesh.

Appendix XXI **Random word pairs from Experiment 9 with semantic relatedness ratings.**

Random word pairs

snake - loofah	1.15
trousers - bag	1.50
chair - worm	1.21
banjo - apple	1.00
octopus - actor	1.00
steak - greenhouse	1.07
barge - parsnip	1.00
train - horseshoe	1.00
bear - drum	1.21
gold - eagle	2.21
uncle - lorry	1.00
turkey - umbrella	1.00
dress - rock	1.00
wizard - saxophone	1.00
road - cockerel	1.14
raft - deer	1.07
wheelbarrow - pig	1.35
spade - animal	1.21
van - rafter	1.00
wardrobe - conjuror	1.28
table - omnibus	1.00
strawberry - coins	1.00
crab - bicycle	1.00
antler - paddle	1.07
bath - scientist	1.07
violin - swing	1.07
crown - whistle	1.00
trombone - goat	1.00
mermaid - pheasant	1.00
spade - wolf	1.00
recorder - turban	1.00
trumpet - face	1.07

hammock - sampan	1.33
turban - dragonfly	1.00
bath - ambulance	1.14
owl - pencil	1.00
geography - pigeon	1.07
cap - pelmet	1.21
botanist - scissors	1.07
apron - worm	1.00